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TERRITORY OF NEW GUINEA.

DEPARTMENT OF AGRICULTURE.

Director	The Hon. G. H. Murray, F.R.E.S.
Entomologist	John L. Froggatt, B.Sc.
Economic Botanist	R. E. P. Dwyer, B.Sc., Agr.
Inspectors and Instructors	F. O. Moody. M. C. Crocker. A. W. S. Corfield. C. C. Marr.
Assistant, Botanic Gardens	L. E. Hanson.
Clerk	B. G. Challis.
Typiste	(Vacant).
Superintendent, Keravat Demonstration Plantation	E. C. D. Green (acting).
Assistant	H. O. Mocatta.
Supernumeraries—	
Assistant Entomologist	B. A. O'Connor, B.Sc.
Inspectors and Instructors ..	W. A. Mossman. G. E. Guthrie. G. W. Stanley. C. G. Francis.
Meteorological Clerk	C. H. Meen.
Nurseryman, Botanic Gardens ..	Ah Fat.
Nurseryman's Assistant ..	C. Namsung.

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Selection of Land.

Peanuts are grown more or less satisfactorily in every portion of this Territory according to the treatment they receive, and are adaptable to most soils and climates. Even in the poor volcanic sand and pumice soils of the Gazelle Peninsula, they give a satisfactory yield grown by natives, and find a ready though limited sale in Rabaul.

A bright coloured shell is preferred by the trade, and for that reason it is advisable to select land of light sandy loam, as the pods are then less likely to be stained or dark coloured. Soil of this nature also permits the "peg" to penetrate and develop beneath the soil, and for this reason dark stiff soils should be avoided.

Although adaptable to almost any warm climate its cultivation is more satisfactory in those districts with wet and dry seasons, or a medium rainfall, as long continued moist weather is apt to make the seeds germinate before thoroughly ripening.

Preparation of the Soil.

If new scrub land is selected for this crop, the only preparation possible is to remove as many roots as possible after clearing and burning off. In land of this nature it is best to use peanuts as an intercrop or catch crop between the lines of young coco-nuts or other permanent crop.

If grass land is used it will need to be very carefully prepared by ploughing or hoeing and removal of all grass roots.

In land which has been covered with a dense growth of kunai it is best to plant and harvest one crop of sweet potatoes before sowing with peanuts, although quite good crops of peanuts have been obtained in newly-cleaned kunai land near Rabaul; but perfect cleanliness at time of planting and during subsequent cultivation is essential.

Animal draught agricultural machinery is practically unknown in this Territory so far, but where good soil conditions prevail breaking up the ground with hoes can be quite satisfactory.

Where peanuts are grown as catch crops in new soil of rich friable nature, good crops have been obtained, but where the land is under grass or has been previously cropped, it should be well prepared if even fair crops are to be expected. The soil preparation required is practically the same as that given in the cultivation of English potatoes.

Sowing.

The quantity of seed required per acre depends on the variety sown, the size of seed and whether pods or beans. Seed is sometimes sown in the pod, but to be sure of satisfactory results it is always advisable to sow shelled seed, as this method is more economical; they germinate more readily, and it is easier to select the best type of seed. (Peanuts can also be propagated by cuttings, two or three of which can be taken from each plant, but this is not a general practice.)

If shelled nuts are used due care must be taken to see that all damaged kernels, or those having the red skin broken, should be discarded. Breaking the pods in two answers almost the same purpose as shelling. Only one plant as a rule develops from sowing an unbroken pod, so that by planting shelled kernels twice as many plants are obtained as when planted whole, besides getting quicker germination.

Many planters make the mistake of sowing peanuts at any time without considering the season, but although there is practically no resting season in plant life in New Guinea, the best time for planting should be considered beforehand. In those districts where the "nor'-west" or wet season commences in December, seed should be sown in January or February according to the climatic condition of the district, the aim being to have the crop ripen during the early part of the "south-east" or dry season. In those districts having a moderate fall of rain during the dry (south-east) season, it is possible to obtain a "dry season" crop also. For this crop the seed can be sown from May to July, so that it will be ready for harvesting before the "nor'-west" season commences.

Seed should be thoroughly matured before planting, as perfectly fresh seed is apt to contain excess moisture which causes the beans to become mouldy and decay. Several complaints of seed not germinating can safely be ascribed to this reason.

All peanuts should be cured, and those required for planting should be carefully selected, as good yields cannot be expected from poor or mediocre seed.

Every planter should endeavour to improve his crops by selecting seeds from plants showing highest yields and best type of pods. These should be sown separately in small beds to supply seed for general planting for next crop, the best plants being selected to supply seed for the crop following. By continuing this process of seed selection the intelligent planter can do much to increase the quantity and quality of his product. The quantity of seed required for sowing depends on the variety, bunch varieties being planted more closely than runners.

Planting Distances.

Planting distance varies with the type of peanut and nature of the soil. The bunch varieties are sometimes closely planted 3 inches to 6 inches apart, planted in rows about 2 feet to 2 ft. 6 in. apart, but in ordinarily good soil of this Territory 12 inches apart in such rows is the planting distance recommended. Runner types are more widely spaced in rows about 3 feet or even more apart, and about 18 inches in the row according to the variety, although very wide planting is not advisable in this Territory owing to excessive weed growth when widely spaced.

By planting shelled seed instead of whole pods there will be fewer misses and consequently a heavier yield, besides less seed being required per acre. The larger varieties of peanuts go from 500 to 1,000 seeds per lb., and the smaller 1,000 to 1,500 to the lb. The quantities of shelled beans required for planting per acre are as follows:—

The larger varieties 500 to 1,000 to the lb. in rows 2½ feet apart and 6 inches in the row will require about 30 to 60 lb.

In rows 2½ feet apart and 12 inches in the row, 17 to 35 lb.

In rows 2 feet apart and 12 inches in the row, 43 to 86 lb.

The smaller varieties 1,000 to 1,500 seeds to the lb. in rows 2½ feet apart and 6 inches in the row will require 23 lb. to 34 lb.

In rows 2½ feet and 12 inches in the row will require 12 to 17 lb.

In rows 2 feet and 12 inches in the row 15 to 22 lb. will be required.

Two or three seeds are planted in a hill a couple of inches apart each way and ordinarily at a depth of about 3 inches deep in light soil and about 2 inches in heavier soils. In certain places, e.g. part of the Gazelle Peninsula, New Britain, where the soil is exceptionally dry, loose, and friable, and evaporation is rapid, it is advisable to sow the seed more deeply, even from 3 to 6 inches. This is a matter which must be left to the discretion of the planter after due consideration of the local conditions.

If the weather is dry it is advisable to soak the unshelled seed for about six to twelve hours to hasten germination. Care must be taken to see that such seed is planted deeply enough to be in moist soil, for if the soil is not in a favorable condition for growth the seed is likely to rot.

Insect pests, birds and rodents are sometimes troublesome after planting the seed, but such damage can be prevented to a considerable extent by the application of one of the following methods:—

(1) Soaking the seed for ten minutes in a solution of 2 per cent. formalin or mercuric chloride (1 in 1,000) solution.

(2) The application of sulphur dust.

(3) Sprinkling with a mixture of equal parts of pine tar and kerosene.

The application of these repellants must be done very carefully when sowing shelled peanuts. In applying the last method it is a good plan to spread the seed on an old tarpaulin so as to permit the sprinkling and stirring in of the mixture as evenly as possible.

In good growing weather germination is rapid; in about four days with shelled seed, but much longer with whole nuts, depending on the moisture and temperature of the soil.

Cultivation.

The soil for peanuts should be carefully prepared and clean cultivation maintained, as the plant is very sensitive to weeds, requiring much the same treatment as potatoes. To obtain maximum results the land should be throughly prepared by removal of all weeds and breaking up the soil. After the ground is in right order the soil should be thrown into ridges as better drainage is ensured and the crop more easily harvested than when grown on the flat. The heavier the soil the greater the necessity for ridging, the object being to provide loose fine soil permitting the lengthened pistil or "peg" to penetrate the soil easily and the nuts to mature evenly, as well as for ease in harvesting. Heavy soil will require more cultivation than that of a light character, as the surface must be kept broken after heavy rains to prevent caking, but after the "pegs" begin to form the plants should be disturbed as little as possible.

In cultivating due care should be taken not to throw any soil on top of the plant, as this would interfere with the pollination and future development of the blossom.

The crop matures more quickly in New Guinea than in Australia or other temperate climes. It will be reduced, however, by the presence of Thurston grass (*Paspalum conjugatum*) and other weeds, consequently it is advisable that it should only be planted in ground that has received clean cultivation or in virgin land. Sweet potatoes, cowpeas, and similar plants which make sufficient cover to keep down grass and other weeds are suitable preparatory crops for peanuts.

Belonging to the family of legumes, the peanut is particularly desirable as rotation with root, grain or other leguminous crops, as it has the power of deriving nitrogen from the atmosphere, which is turned by the action of micro-organisms in the root nodules into nitrates in an assimilable form. It should not, however, be planted more than three times continuously on the same piece of ground. Owing to the fact that most of the plant is removed from the soil at harvesting the peanut does not benefit the land to the same extent as other leguminous crops, so that soil building or green manure crops like various species of *Crotolaria* should be included in the rotations.

Harvesting.

In the humid tropics, where growth is continuous, it is not so easy to notice when peanuts are ripe, as in the sub-tropics or temperate zone, where there is a wintering season, but the following particulars will be of assistance in judging when plants are ready for harvesting:—

(1) When the foliage loses its bright fresh green and becomes yellowish or dull green.
(2) The veins in the inside of the pod should be dark in colour.
(3) The period of growth.

The quick-growing bunch varieties are ready for harvesting in 105 to 125 days and running types 165 to 185 days. When grown on an extensive scale the harvesting is generally done by a plough without mould board, but in the present state of development in New Guinea, digging with fork or long-pronged hoe must suffice.

If the vines are left in the ground too long the ripe nuts are apt to become detached from the roots, resulting in considerable loss of crop. In very humid weather, also, the seeds are apt to germinate in the pod if left in the ground even a few days after maturity. On the other hand, if harvested too soon, there will be too many duds or pops, and immature nuts which will shrivel up and be valueless. Careful judgment must, therefore, be exercised when deciding on the right time for harvesting. It is advisable to loosen the soil before lifting the plants. Harvesting should not be done when the plants are wet, as the vines in such a condition may start to rot and thus interfere with the subsequent curing of the nuts. After harvesting the crop must be cured, as this enables many imperfectly ripe pods to complete the process and prevent shrivelling of the beans.

Curing.

The pods should be carefully harvested, removing as much soil as possible from the roots, which are then spread on the surface of the ground to the full exposure of the sun for a few hours to wilt. The bunches should then be stooked to complete maturing and ripening. This is done by stacking the clumps of plants around central poles about 6 feet high and about 3 inches in diameter, pointed at both ends and driven securely into the ground. About 30 poles will be required per acre, and it is advisable that the holes should first be made with crowbar to ensure that the poles are absolutely firm. If this is not done the stack may develop a lean or be blown down with the wind.

Two pieces of timber about 3 feet in length should be fastened at right angles to the pole at least 1 foot from the ground to prevent the bottom layer of the stack from rotting, and assisting in the aeration of the middle of the stack, for it is absolutely necessary to see that no part of the vines comes in contact with the soil. Hardwood 3 inches by 1 inch is best for the cross pieces, but as this is not always easily obtainable, suitable bush hardwoods or even stout limbong (split palm stems) can be made to serve the purpose. The clumps of vines are then arranged round the poles with the roots towards the centre, first arranging a few vines as a foundation on which to build up the stack, care being taken to see that they are pressed occasionally to make the stack secure. At the same time the stack must not be pressed too heavily, and it should not be more than 2 or 3 feet in height, otherwise heating will result and the crops be damaged.

The time required for curing depends greatly on the prevailing climatic conditions, but ordinarily it will be from three to six weeks. The stacks must be inspected frequently to see that they are not suffering from the depredations of rats or other vermin. They should be thoroughly cured before storage, otherwise they are very apt to heat and become mouldy, rendering them practically valueless.

It is absolutely necessary to see that the roots and pods are entirely free from soil, or full development of the oil known as curing will be prevented. The nuts should not be removed from the vines until they are cured or the kernels will shrivel and pods become mouldy. If the weather is suitable for curing, the vines will have wilted sufficiently to start stacking within a few hours after digging: they should be stacked while the leaves are still limp and before they become crinkly and brittle. In making the stack the vines should slope outwards and downwards so that the pods will be near the centre where they can have free upward circulation of air and yet be protected from the weather.

It will be of assistance in keeping the stack firm and secure if a bunch of vines is occasionally twisted round the pole. The centre of the stack should be kept about 12 inches higher than the outside, and so constructed that when complete the top will have sufficient slope to shed rain. Improperly stacked nuts will ferment, and for that reason they should not be more than 3 feet in diameter. When completed the stack should be fastened to the stake by a few vines in such a way that it is perfectly secure. Finally the top of the stack should be covered with a little thatch of kunai or palm leaves, sufficient to shed any rain, but due care must be taken that it is not put on in such a way as to interfere with free circulation of air, also on no account should green or wet material be used for this purpose or fermentation will invariably ensue.

A roof shelter similar to that given by good native cultivators in curing their yams before storing is a very suitable guide for covering the peanut stacks during the process of curing. Peanuts are sometimes seen curing in open sheds, but this is not advisable, in the first instance, as they cure more satisfactorily in properly made stacks. Stacking is the only way of curing nuts satisfactorily and the vines should remain three to six weeks before removal to sheds for picking the nuts.

The outside of the shell must be clean and bright as purchasers for roasting purposes will not accept them in any other condition. They must also be thoroughly dry, otherwise the kernels will be mouldy and valueless. Buyers in all parts of the world lay great stress on these points.

Picking.

After curing has been completed the peanuts should be picked from the vines, a process rather slow and tedious by hand, which particularly with native labour cannot be considered cheap, but machinery for this purpose is only suitable when the crop is produced on an extensive scale.

Separation of pods from the roots is best done on a bright hot day and care should be taken that all immature or rotten pods should be discarded. One reason for the adverse report on the few peanuts shipped from this Territory is due to the fact that care was not taken in this matter, as marketable pods must be bright, clean, and free from stems and other refuse.

Though not a very satisfactory method, the pods can be removed by rubbing the whole plant over a tightly drawn piece of wire netting which lets the nuts fall through. Much trash falls through also, but this can be removed by winnowing. One of the disadvantages of this method is that many of the stems remain on the nuts, but if they are thoroughly dried afterwards and receive a further winnowing a fairly clean product will be obtained.

The nuts can be threshed by dragging the vines over wire netting strained taut on a horizontal frame. The vines should be dry and brittle when picking, otherwise the nuts will not detach readily; consequently this work should not be done in damp weather.

Washing.

Most growers wash and dry the peanuts before shipment, but this should not be very necessary with peanuts that are intended for oil crushing provided sufficient care is taken in all previous operations of harvesting, curing, winnowing, &c.

To get a perfectly clean sample, however, the peanut should be washed in several changes of water and then dried in the sun, which is the method frequently employed in China and other Eastern countries. When so treated the pods have a bright clean appearance essential for the confectionery trade.

The appearance of the nut can be greatly improved by washing in a bleaching bath, then in fresh water and subsequently dried.

Winnowing.

After picking over the nuts on completion of curing they should be winnowed in a strong wind, which is easily done by pouring the pods from a stage 7 or 8 feet from the ground on to a clean floor or mats in the open. A barbecue or cement floor fully exposed to sun and wind should be on every plantation for dealing with peanuts, rice, or any other crops which require to be winnowed or sun dried.

Bagging and Storage.

Peanuts may be stored in bags when thoroughly dried, but the shed or house in which they are stored must be thoroughly water-proof, rat-proof, and ventilated. If stored in bags the tiers should not be more than seven tiers high with alleyways at every third row. They should not be bagged or stored until thoroughly dry or they are almost sure to ferment and be unfit for market. When grown on an extensive scale as in many parts of Southern United States of America,

mechanical pickers are used, but such machines are not applicable to the small cultivators in this Territory. If to be stored in store or sheds any time before shipment the bags should not be stacked directly on the floor, but saplings should be placed underneath to provide circulation of air. The store should also be made rat-proof by lining with wire netting not more than ½-inch mesh.

Crop Returns.

Yield varies according to the variety, soil characteristics, cultivation received and climatic conditions. Other things being equal the highest yield will be from the crop is planted in the wet season in time to reach maturity at the beginning of the dry season.

The average yield for the entire United States of America was 728 lb. per acre. Under the best conditions yields of 1,400 to 1,600 lb. per acre are frequent, but in various parts of the tropics yields of 2,000 lb. and even 4,000 lb. (in Barbados) are recorded.

Market.

There is a limited market in Australia for peanuts from this Territory, but brokers who have been in communication with the Department of Agriculture, Rabaul, insist on having them shelled. There is no doubt some saving in freight when shipped in this condition, but on the other hand there is greater risk of the shipment being damaged by weevil and other vermin as well as being tainted by copra and other strong smelling cargo in the ships' holds. There is also danger of the kernels being bruised in transit, resulting in fermentation setting in.

Varieties.

There are various types of both bunch and runner peanuts in cultivation bearing large and small nuts. The larger nut is preferred in the confectionery trade, but the smaller being heavier, bulk for bulk is preferred by the oil crusher.

The runner varieties are more difficult to harvest and to cure satisfactorily owing to the pods being distributed along the vines instead of being in a cluster at the base of the plant as in the bunch varieties. There are four varieties in cultivation at Keravat, the average time of yield has been as follows:—

Red Spanish	4½ months
White China	5 „
Shantung	4½ „
Pearl	3½ „

The average yield of all the above is ½ ton per acre varying according to climatic conditions and nature of soil. The largest crop obtained has been from Red Spanish which on a few occasions has yielded 1,400 lb. per acre.

As the peanut therefore reaches maturity in a few months it is very suitable as a catch crop to be given with those of a permanent nature.

Uses.

More than 100 products can be obtained from peanuts, including oils, milk, butters, flours, meals, breakfast foods. It is also used in canning sardines and other fish, relishes, sauces, flavourings, confectionery of many kinds, wood stains, stock feeds from both nuts and vines, black ink, face powders, face creams, harness

dressing, in medicine, various arts, &c. Its easy cultivation and adaptability to varied soil conditions, and particularly its value as food for human beings and stock, apart from other economic purposes, should be sufficient to warrant its cultivation in New Guinea. Every part of the plant can be put to some commercial use, even to the residue resulting from processing the beans in the many forms in which it is now put on the market.

The beans are the richest of all vegetable foods, the oil being of excellent quality, little, if at all surpassed by the product of the olive. It is the basis of many valuable food products and according to the *American Nut Journal,* analysis shows it to contain three times the nutritious value of beef. It is therefore one of the best vegetable substitutes for meat and for that reason is greatly esteemed by believers in a vegetarian diet. It can be used in many forms, roasted or boiled in the shell or as peanut butter, and several recipes are given below for the information of the house-wife.

Its food value can be well appreciated when it is realized that the beans contain 29 per cent. protein and up to 50 per cent. fat. Apart from the economic value of the whole bean the residue after expression of oil can be processed into flour which is also an important food for human beings. After final pressure the residue still contains about 5 per cent. oil, and after thorough drying, grinding and sifting becomes a flour of high food value with a very pleasant taste. It is somewhat deficient in carbohydrates and it is advisable therefore to mix it with wheaten flour, and in this way can be turned into various nutritious articles of diet.

To popularize the use of this valuable product as an article of diet, the following recipes common in many parts of the southern United States of America are supplied:—

Salted Peanuts.

If green or unblanched nuts are used they must be first blanched in boiling water for five minutes to loosen the skins. Use two cupfuls of water to one cupful of shelled nuts. Drain, remove skins, and let dry, over night if possible.

Browning the Nuts in the Oven.

Put one-half cupful of nuts and one teaspoonful of oil in a flat pan and roast in a moderately hot oven, about 450 degrees Fahrenheit, for five minutes, if roasted peanuts are used, or ten to fifteen minutes if green or unroasted nuts are used. Stir frequently so as to keep uniform in colour. When golden brown put between paper towels or on brown paper to drain off any excess of fat. Put on waxed paper and sprinkle with salt in the proportion of a teaspoonful to each cup of nuts. A larger amount of salt may be used if desired.

Nut Chowder.

Cut two potatoes and one large onion into thin slices. Cut two tomatoes or the equivalent of canned tomatoes. Dissolve a teaspoonful of peanut butter in one-half cupful of cream or milk. Put all the ingredients into a quart of water with two tablespoonfuls of chopped nut meats, simmer until the vegetables are tender, then add salt and a tablespoonful of butter just before serving.

Fruit and Nut Paste.

Take 2 cupfuls of dates after stoning, 1 cupful of peanut butter, 1 teaspoonful of salt. Wash and dry the dates and put through a meat chopper, add the peanut butter and mix well with the salt. Take spoonfuls of the mixture, shape into small apples, put a currant for the blossom end and a piece of candied lemon or orange peel for the stem.

Prune Salad.

Prunes, lettuce, chopped peanuts, mayonnaise and peanut butter. Cook prunes as if for sauce, but omit sugar. Cool, remove stones, and fill cavity with peanut butter.

Tomato and Peanut Soup.

1½ cups stewed and strained tomatoes.
½ cup peanut butter.
1 teaspoon salt.
¼ teaspoon paprika.
2½ cups boiling water.

Add tomatoes gradually to the peanut butter and when smooth add the seasonings and water. Simmer for ten minutes and serve with croutons. Well-seasoned soup stock may be substituted for the water; but if used, the quantity of salt should be reduced.

Peanut Butter Loaf.

2 cups bread crumbs.
1 cup cooked rice.
½ cup chopped stuffed olives.
¼ teaspoon dry celery salt.
½ cup peanut butter.
1 teaspoon onion juice.
2 teaspoons salt.
2 eggs.
½ cup milk.

Mix the ingredients and form into a loaf. Bake until brown. Serve with a tomato sauce.

Peanut Butter Canapes.

Cut rounds of bread and toast to a delicate brown.

Mix peanut butter with cream cheese, add salt, spread lightly on the toasted rounds and serve.

Peanut Butter Omelet.

4 eggs.
4 tablespoons milk.
6 tablespoons peanut butter.
1 teaspoon salt.

Mix the peanut butter with the milk. Separate the whites and yolks of the eggs and beat well. Blend milk with the beaten yolks and fold in the beaten whites. Brown the omelet and fold. Serve on a hot platter with a cream or tomato sauce.

Peanut Butter Fondue.

3 eggs.
6 tablespoons peanut butter.
¾ cup milk.
1 teaspoon salt.
1 cup dry bread crumbs.

Blend the peanut butter with the milk and add the beaten yolks and the bread crumbs. Fold in the stiffly beaten whites. Pour into a baking dish or individual baking cups, surround with hot water, and bake until firm.

Peanut Butter Bread and Cookies.

Peanut butter is also good in various hot breads or in cookies. When used for such purposes the fat specified in the recipe may be greatly reduced or the peanut butter in some cases may entirely replace it; for instance, in baking powder biscuits, peanut butter may be used in place of other fat.

Peanut Butter Salad Wafers.

1 cup cornmeal.
1 cup wheat flour.
½ cup peanut butter.
1 teaspoon salt.
½ cup milk.

Mix together, roll out very thin, and cut out. Bake in a moderate oven until brown.

Oatmeal Peanut Butter Drop Cookies.

½ cup sugar.
¼ cup syrup.
8 teaspoons peanut butter.
¾ teaspoon salt.
2 eggs, well beaten.
2½ cups rolled oats.

Mix together and drop by the spoonful on a greased baking sheet. Bake until brown.

Peanut Butter Cake Filling.

½ cup syrup.
1 tablespoon vinegar.
¼ teaspoon salt.
2 tablespoons peanut butter.
The white of 1 egg.

Cook the syrup with the vinegar until it forms a hard ball when dropped in cold water. Pour over the beaten egg white and beat until stiff. Add the peanut butter last thing. Spread between the layers of a simple 1-egg cake or sponge cake. Serve with a fork.

Peanut Candy.

1 pound brown sugar.
1 cup molasses.
1 cup water.
4 tablespoons butter.
¾ pound shelled peanuts.

Boil sugar, molasses and water till it is crisp when dropped in cold water. Just before taking from the fire add the butter and the nuts, then pour into pan well oiled with butter.

Value as Pig Food.

The whole plant is of value as pig food, and as the greater part of the pork consumed by Europeans in the Territory is imported from Australia as freezer cargo, the possibilities of a profitable pig-raising industry near the main centres of population are considerable, and peanuts are worthy of cultivation for this purpose alone.

It has been proved that less than 3 lb. of peanuts are required for each 1 lb. gain in the weight of pigs that weigh over 40 lb. at the start. An acre of peanuts pastured by pigs made over 1,200 lb. of gain, while an adjoining field of maize yielding 30 bushels per acre only gave 436 lb. of gain per acre on pigs.

Peanut meal, the residue after extraction of the oil, contains about 52% protein, 8% fat and about 27% carbohydrates (starch and sugar), which proves it to be one of the most highly valued stock foods on the market. Even the leaves and stems also provide a nutritious hay appreciated by most domestic animals, and for this purpose alone several years ago were considered in the southern United States of America to be worth about £5 per acre. The vines and leaves are also of value as green manure if not used for hay.

Pests and Diseases.

Certain insect pests have been recorded on peanuts grown at the Keravat Demonstration Plantation, but they are not of sufficient importance to warrant drastic combative measures. A root disease has been noted at Keravat, but its appearance has been sporadic and there is no evidence to indicate that it is of a serious nature. Rosette disease which has been causing considerable damage to peanuts in some countries is so far unknown to New Guinea.

Oil Extraction.

This is a simple process, but in the United States of America where the crop is put to so many uses, special machinery is used for dealing with it in large quantities.

The nuts must be thoroughly cleansed and have the red skin removed by washing, drying and winnowing. The cleansed kernels are then subjected to heavy pressure in hydraulic mills which is always done when cold to obtain high grade oil, colourless with pleasant odour and flavour. Further pressure under heat provides oil of inferior quality suitable for soap-making and other industrial purposes.

Machines now put on the market by British, German and American engineering firms, are known as oil expellers, and reduce the amount of machinery required to a minimum.

If a number of planters and others would form a co-operative concern for dealing with this crop it should pay them to crush the nuts locally and use the residue for stock feed as noted elsewhere in this article.

Fertilizers.

Peanuts require an ample supply of organic matter in the soil, but this will be found in most newly cleared land in this Territory. Lime, when easily procurable, can be applied with advantage to most soils in New Guinea, but investigations on this crop indicate that the quality rather than the quantity of the crop is affected by such applications. When supplied with a sufficiency of lime peanuts are whiter in colour and weigh more per bushel, than soils lacking in this element. At the same time an excessive application is very apt to do more harm than good by causing a reduction in yield. Before deciding on any such application it is advisable to make a simple test of the soil for acidity, or to make only a moderate application of about 500 lb. of lime per acre.

Soils deficient in lime show such marked benefit by its moderate application that when easily obtainable any opportunity of using it should be taken. If not convenient to use burnt lime, crushed limestone or fresh coral can be applied with advantage.

Heavy crops are obtained on new ground for the first few years without manure or fertilizers, as the ashes and bush scraping after burning off will provide potash and other valuable fertilizing elements to the soil.

THE LONG-HORNED TREE-HOPPER OF COCO-NUTS SEXAVA SPP.

(*John L. Froggatt, B.Sc., Entomologist.*)

This pest is commonly known as the "Coco-nut grasshopper", but the term "grasshopper" so applied is decidedly a misnomer, and leads to confusion with the "grasshopper" of plague fame, that is common in so many parts of the world, and which belongs to a totally different family of insects and varies both in structure and habits. The plague grasshopper belongs to the *Acrididae,* which have short antennae (feelers) and are ground feeders, whereas the Sexava belongs to the *Tettigoniidae,* which have very long antennae and are essentially arboreal in their habits; there are many other differences, but these will suffice for the occasion.

Two species of Sexava have been identified from this Territory by the Imperial Institute of Entomology, from specimens submitted—

(*a*) *Sexava nubila, St.*—from Madang, New Britain, New Hanover, Sepik and New Ireland.

(*b*) *Sexava novae-guinea, Brancs.*—from Manus and New Hanover.

All stages of this pest feed on the foliage of the coco-nut palm, and where present in plague form they will practically completely defoliate the palms, resulting in such a setback as to stop production for eighteen months to two years.

Sexava is distributed generally throughout the Territory of New Guinea, with the exception of the Kieta district (the northern portion of the Solomon Islands Group), and some of the outlying islands which, as far as is known, are free from this pest. The most heavily infested district generally is the Manus area, although there are parts of New Ireland, New Hanover, and New Britain that are at times very severely attacked.

There are curious anomalies in the dispersion of Sexava for which no reason can be assigned, as for example the Seeadlerhafen Group in the Manus district, comprising the islands of Koruniat, N'Drillo and Hawai; these lie between Mokareng Plantation and Pitelu Island, which are both Sexava infested, whereas these islands are free, although Koruniat is only separated from Mokareng by a narrow strip of water, as also is N'Drillo from Koruniat. There are numerous other instances of a similar nature.

The only other record of Sexava spp. as a pest of coco-nuts is from the Moluccas group of islands and that portion of the main island of New Guinea in the Dutch Territory; in some parts of this area the pest is as serious as in the worst areas in this Territory, but in others it has never been known to cause serious damage. *Sexava nubila, S. coriacea* and *S. karyni* are recorded from the Dutch Territory.

Research investigations into the Sexava problem were started in detail in the latter half of 1929, with observations on the life-history, habits, &c., of the pest, both in the laboratory and the field; data in relation to the dispersion and relative severity in the various localities of the Territory were also collected.

In 1932 the Sexava Research Station was instituted with the appointment of an Assistant Entomologist, the first appointee being Mr. N. E. H. Caldwell, B.Sc. The station was first posted to the Manus district at Sissi Plantation, then at Pak Plantation and later with Mokareng Plantation as head-quarters, operating

from the last-mentioned centre from Loniu village through Papitalai, Lombrum, Salami, Mokareng Plantation to Pitelu Island. In May, 1934, the Research Station was moved to New Hanover, in the Kavieng district. Mr. Caldwell left in May, 1933, to take up a position in Queensland, and the position was filled in September, 1933, by Mr. B. A. O'Connor, B.Sc., the investigations in the intervening period being re-organized and carried on by the Entomologist, under whose direction and supervision the work of the station is carried out.

LIFE HISTORY AND HABITS.

The Egg.

In general, the majority of the eggs are deposited in the soil, but in New Hanover they appear to be fairly evenly distributed in the soil, the epipthytic growths on the palm trunks and the crown of the palm.

In laboratory experiments it has been found that where gravid females are placed on soils of the following physical conditions, namely (1) loose moist sandy loam, (2) slightly compacted moist sandy loam, (3) well compacted moist sandy loam, (4) moist heavy soil, (5) dry soil, the greatest number of eggs are laid in the loose moist sandy loam. This has been borne out by field observations. In the collection of eggs in the plantation, a greater number of eggs are collected in bare sandy patches than in any area of similar size elsewhere in the plantation, although they will be found anywhere in the infested area.

Rotting logs and the bases of rotten fronds are also common sites for oviposition.

Oviposition always occurs at night in the plantation, but in the laboratory, where the females have been confined in small wire-gauze cages, eggs have been laid in Rabaul between 8 a.m. and 3 p.m.

Eggs are always laid singly, although three or four may often be found close together as if deposited in succession by the one female, the ovipositor having been withdrawn after deposition of each egg.

The egg when newly deposited is light brown in colour and measures about 9 mm. long, being flattened laterally; when fully developed, it measures about 11 mm. long and is considerably swollen. When deposited in wet ground the colour is much darker, the "shell" being somewhat discoloured.

In the field they are generally about half an inch below the surface of the soil, with the micropilar end upwards, but the orientation in the soil does not appear to very materially affect the emergence of the nymphs, as shown by laboratory tests in which the eggs were buried in loose moist soil at all angles and up to half an inch in depth; emergence is affected if the soil becomes compacted and possibly with greater depths of covering soil than that given above.

From laboratory observations on female Sexava collected at night ascending the palms, it seems probable that all the mature eggs in the ovaries are not necessarily laid at the one time. Females so collected and caged soon after collection have deposited eggs the same night. It is, of course, possible that they had been disturbed before completing oviposition, but it has occurred on so many occasions that it can hardly be accidental on every occasion. This is also borne out by other observations, referred to below.

A single female has laid as many as 16 eggs in one night, but generally the number is much less. The average total tumber of eggs laid by a single female in her lifetime is 20-30, but as many as 41 have been recorded. From counts made in Rabaul from two or more females collected in the field and caged together, an average of 39 has been found, the average of individual lots rising as high as 49 per female.

By dissection, as many as 30 apparently mature eggs have been counted from a single ovary, with in addition more than 20 in various stages of development.

The period from deposition of eggs to emergence of nymphs varied from 42 days to more than 100 days, although the majority matured in under 60 days. On New Hanover the egg stage has occupied from 56-85 days, average 61.8 days.

The average fertility of eggs collected in the field was 87 per cent., although as high as 91.7 per cent. has occurred. The average hatching from these eggs was 82 per cent., although in some lots it was as high as 91.7 per cent.

The eggs can withstand very adverse conditions and still yield a percentage of nymphs, although such may be low. Eggs exposed in dry soil for 119 days and then transferred to moist soil for one week, yielded a few nymphs within ten days.

A high moisture content of the soil, provided no water is lying on the surface, does not appear seriously to affect the maturation of the eggs.

Oviposition continues through the life of the female, but is greater in the early than the later stages of life.

From tests carried out in the laboratory, it has been found that eggs laid on the same night usually hatch about the same time, but laid on even successive nights by the same female, they show a greater variation in time in reaching maturity.

In order to test the statement that birds spread Sexava through scattering eggs after devouring gravid females, apparently mature eggs were dissected from the ovaries and incubated in the usual manner; in not even a single case did they yield nymphs.

The Nymphs.

On emerging from the egg, the nymph is covered in a fine membrane, which is shed as soon as it reaches the surface of the soil; this is known as *vermiform larva.*

Emergence in the field occurs apparently in the early evening and the nymphs ascend the palms within a maximum of 24 hours. Sometimes, however, nymphs have emerged in the laboratory up to 11 a.m.

When newly emerged, the nymph is a dark green in colour, but as development advances this becomes much lighter, and in the second and subsequent stages it is a light green, although brown variants are not uncommon.

The nymph resembles the adult in general form, but has no wings and is not sexually mature. It develops by a series of moults, of which there are apparently six in the male and seven in the female, the former taking 20-22 weeks and the latter 21-26 weeks to reach the adult stage.

The first stage nymph is very much more active than the later ones, and is much more easily disturbed.

The first instar measures 9-11 mm. in length, and about 2 mm. in width across the thorax, while the antennae measure about 36 mm. in length. The sixth male instar measures 38-46 mm. long and the seventh female instar 43-53 mm. in length. On New Hanover the measurements are respectively, first instar average 15 mm., sixth male average 49.1 mm., seventh female average 54 mm.

Feeding time begins soon after emergence of the first instar, such beginning at the tips of the leaflets of the more mature fronds, and gradually spreads upwards through the fronds in succession. The new fronds are very seldom touched until the other foliage has been largely devoured. The reason for this appears to be the furry nature of the young leaflets, which apparently cloggs the mandibles, especially of the younger stages. Prior to moulting the nymphs practically cease feeding for a short period.

The food consumption of the early instars has not been worked out in actual figures, but is relatively light; it gradually increases through the various stages until with the last stage nymphs it is about 3.3 square inches per individual per 24 hours, about the same as that of the adults. Without food the nymphs in all stages will live for about one week.

The nymphs as well as the adults have a very definite water requirement per day, which is normally filled by rain or heavy dews on the foliage. In the insectaries this is maintained by spraying the fronds with water once or twice each day.

The complete life cycle, i.e., from deposition of the egg to the emergence of the adult, occupies about 4-5 months, or even more. To give one specific case, observed in the insectaries in Rabaul, the egg period was 65-66 days, while the nymphal stages occupied 78-82 days, a total of 143-148 days.

On New Hanover, Sexava males have taken an average of 88.5 days from emergence to maturity and the females over 100 days.

The Adults.

It is only in this stage that the "hoppers" develop wings, and are sexually mature.

The adults are generally green in colour, although brown variants often occur; in New Hanover, however, all the adults are brown.

The following summary gives the relative sizes of the two sexes, the figures being an average of a considerable number of measurements:—

	Male.	Female.
Body	48-57 mm. (1.9-2.3 in.)	57-63 mm. (2.3-2.5 in.)
Head to tip of folded wings	78-83 mm. (3.1-3.3 in.)	86-92 mm. (3.4-3.7 in.)
Ovipositor	—	31-33 mm.
Antennae	209 mm. (2.3 in.)	—

On New Hanover the average body length of males is 66.3 mm. and females 72.7 mm.

In cages in the laboratory the adult life is from 4-12 weeks, the males having lived for as long as 71 days, and the females for as long as 90 days, 4-6 weeks being common.

Many counts have been made of the proportion of males to females from adults collected in the field and bred in the laboratory, as a result of which it appears to be about 55 per cent. females and 45 per cent. males.

The powers of flight are very poor, the wings more generally serving as a means of "volplaning" to the ground; instances have been noted where adults, disturbed from the crowns of palms, have sustained a flight of up to 50 feet on to another palm without losing elevation, but this appears to be a maximum. Their power of holding on to the foliage is undoubtedly great, although adults and nymphs, especially the latter, are often dislodged by high winds.

They normally shelter during the day on the undersurface of the leaflets towards the base, such being the largest part and thus affording more shelter. Their general colouration conforms very closely to that of the foliage on which they are resting.

Feeding is usually confined to the night, but on dull days a small amount may be consumed during the day. The food consumption of the adults is about 3-4 square inches per individual per 24 hours.

Copulation apparently takes place at night on the palms. Although the act has not been actually observed caged specimens have been seen under obvious sexual excitement in the early evening, but the use of light apparently inhibited the act.

Stridulation is a function of the males only, and may be heard at any time of the day or night; it does not appear to be necessarily associated with sexual excitation.

Observations at night in the field have shown that in the Manus and New Britain areas numbers of adults come down from the palms at about dark and ascend the palms from about 7 p.m.; at these times females are much more numerous than males. This movement of the adults is very greatly influenced by climatological factors; on moonlight or dark dry nights relatively few adults leave the crown of the palms, but on dark nights after rain, especially in the afternoon, the numbers descending are very considerable.

Other food plants of both adults and nymphs are principally the leaves of banana, Heliconia, wild sugar cane, sago and Areca palms. In some parts Heliconia is reported to be preferred to coco-nuts.

Dispersion.

The pest is so widely distributed throughout the Territory that the question of dispersion rather applies to localized areas, except in the case of the Kieta district.

Both the transportation of soil and apiphytic growths and orchids from an area infested with Sexava may lead to the carrying of eggs from one place to another, especially the epiphytes and orchids.

Coco-nut fronds have been found on canoes amongst the islands of the Siassi group carrying both nymphal and adult Sexava. Baskets of coco-nut leaf made in kanaka villages have also been found to be sheltering Sexava. Both of these sources may lead to localized dispersion of the pest.

In any one area such as a plantation, the dispersion from one part to another is undoubtedly gradual. This pest does *not* swarm, and therefore there is no mass migration. It has been observed that adult Sexava "volplaning"

down to the ground at night or late afternoon, land many feet from the palm which they had left; any wind at the time will extend this distance. Where this procedure continues over a period, eggs will be laid many rows away from the original, and the centres of infestation be gradually spread farther afield.

Where fronds of adjacent palms overlap, a certain amount of migration will take place by these natural bridges.

Infestation is practically always worst on the loose sandy soils, although it has also occurred in more or less plague form in areas where the soil is of a more clayey nature.

Control.

Although mechanical measures, if carried out sufficiently in the early stages of an outbreak, will give a good measure of control of the pest, where the value of the product (copra) is so low, the cost has necessarily to be considered.

Biological Control.

The alternative of biological control, therefore, offers a field worthy of thorough exploration, even although if successful, its result must necessarily be slow in coming to fruition.

The search for local parasites (i.e. those already in any district of the Territory) has received very careful attention, and some very interesting results have been obtained.

Moreover, in February, 1933, the Entomologist was commissioned to visit Amboina, an island of the Moluccas Group in the Netherland East Indies, to study certain parasites of Sexava eggs recorded from that locality by Dr. Leefmans. Colonies of the principal one, *Leefmansia bicolor* (a species of *Encyrtidae*) were bred in Amboina to ensure freedom from hyperparasites and successfully landed on Manus in April, 1933.

Breeding operations were immediately commenced at the Research Station, and this wasp was proved to breed freely in the eggs of the *Sexava novae-guineae* (and later of *S. nubila*), a distinct species from that in Amboina (*S. coriacea*); breeding was carried out through three generations to ensure absolute freedom from hyperparasites. The numbers emerging were sufficiently large in June to permit of the first liberation in the field being made on 26th June on Mokareng Plantation. Later the area of liberations was enlarged to embrace several other plantations and kanaka groves; a large number of parasitized eggs were supplied to two planters in the Manus district at their own request, to enable them to breed these wasps for themselves for distribution over their properties, which were too far away to enable liberations to be made direct from the Research Station.

On 12th September, 1933, the first presumptive evidence was obtained that *Leefmansia bicolor* was apparently breeding under natural conditions in the field by an emergence in the storage jars of adults in a period markedly below the normal life-cycle. Later the breeding of *L. bicolor* in the field was definitely established. In conjunction with the mass breeding for liberation, a study was made of the life-history, habits, &c., of *L. bicolor*.

Mass breeding is carried out in glass preserving jars and small wire gauze cages (12 x 12 x 15 with three trays) as containers for submission of the Sexava eggs to the parasites, food being provided in the form of sugar syrup on blotting paper or calico. After 4-6 days in these jars, the eggs are taken out and placed

in large tubes or small bottles, in which they are stored until the parasites emerge. The wasps being strongly attracted to light, are then readily transferred by plugging the neck of the storage jar into that of the submission jar, and the base of the latter turned towards the light, the former being covered with a cloth to make it darker.

After removal from the submission jars the parasitized eggs are spread out to dry for a few hours, otherwise it was found that a degree of "sweating" was liable to occur during storage, leading to the death of considerable numbers of parasites. Under conditions of "sweating" a number of small Diptera (flies) emerged, apparently from the Sexava eggs, but the actual relationship between the two could not be determined.

The period from submission of eggs to first emergence of the wasps was 25-27 days in Manus, and 29-30 days in New Hanover, the difference being due to the lower temperature in the latter locality, especially at night.

The males measure about 1 mm. and the females 1.3 mm. in length; the head and abdomen are black with the thorex reddish yellow. The males are readily distinguished from the females by the antennae, those of the males being all black and those of the females having the club and two first apial segments white.

As many as 50 of the wasps have emerged from a single Sexava egg, the average being 20-30. All the wasps from one egg generally emerge within 24 hours of the first emergence. A number of instances, however, have been noted from mass lots of parasitized eggs in which a definite hiatus in emergence has occurred, varying from 14-56 days (average of 40 such cases being 25-26). After the first emergences are all completed a second series carries on for a period of 2-6 days.

All lots of parasitized Sexava eggs used in field liberations of *L. bicolor* in New Hanover have been divided into two parts, the larger portion is placed in wire gauze field liberation boxes, and the remainder held in the laboratory, partly for check observations on the degree of emergence of the parasites, and partly to use the emerging wasps for further breeding work; the eggs are not set out until a few days prior to the date of emergence. The boxes are returned to the laboratory about one week later, and the eggs so returned are held for a period of observation. From this work it has been found that the parasites emerge over markedly longer periods from the eggs set out in the field than they do from the check lots held in the laboratory; possibly parasites of relatively low vitality in the developmental stages resulting from a very heavy degree of parasitization of individual Sexava eggs succumb in storage in the laboratory, but emerge under the field conditions.

Sexava eggs in lots of 10-20 exposed to a single female *L. bicolor* have yielded as many as 19 parasites, the average being 17. These conditions being unnatural, it is probable that these figures do not represent the maximum number of eggs laid per female wasp in the field or even in mass infestation in the laboratory, but give an indication of a possible rate of increase.

There is a definite period after, and apparently before, which effective parasitism cannot take place, but the limits between which this is possible comprise at least two-thirds of the period for maturation of the egg.

Selected Sexava eggs parasitized in small lots gave an emergence of 64.5 per cent. with an actual parasitism of 82.4 per cent.; 17.9 per cent. died in the

larval stage, due apparently to the desiccation of the host. Under conditions of mass breeding, where all eggs collected are used in the submission jars without any selection being made, an average parasitization of 50-55 per cent. is obtained.

The adult wasps live for up to 14 days (average 8-9 days) when fed continuously on sugar syrup, but die within 24 hours when without food.

In order to test the ability of the wasps to emerge through soil, parasitized eggs were buried in moist soil at varying depths, and emergence readily took place, through up to three-quarters of an inch of moist sandy soil.

Field liberations were first made by liberating the live wasps soon after emergence, but this so limited the scope of the area that could be covered that small wire gauze cages (4 inches x 4 inches x 1 inch) were tested out with satisfactory results. It was later found that smaller cages (2 inches deep and 2 inches diameter) were more suitable, and are now the medium used for all field liberations. These are covered with a lid to keep out rain and hung by a wire to stakes driven into the ground at an angle sufficient to let the cages hang free.

A scheme has been prepared by which any planters who care to, can breed these wasps for themselves for liberation in plantations beyond reach of the Station, full particulars of which can be obtained on request to the Department of Agriculture, Rabaul.

It must be stressed that, in order to give a reasonable chance for the parasites to become established in any area, a series of liberations extending over at least 2-3 months, if not more, must be made.

The first liberations in New Hanover were made on 14th May, 1934, and the wasps have been recovered from several centres of liberation, and also from two centres in which no liberations have been made. These latter are up to three-quarters of a mile from the nearest site of liberation.

Local (Indigenous) Parasites.

Manus.

In the Manus area three parasites of Sexava eggs were bred from material collected in the field—

(1) A small species of *Mymaridae* (female about 7 mm. in length) was bred from eggs collected in the epiphytic growths on the palm trunks; however, this appeared to be rather a casual parasite of Sexava. The eggs of another species of *Orthopteron* present in the same situation in considerable numbers were regularly parasitized by this wasp.

(2) A species of *Eulophidae* (female about 1.8 mm. long) was bred from eggs collected in the soil, and although this appeared to be a primary parasite of Sexava it was comparatively rare.

(3) Two species of *Scelionidae* were also bred from eggs collected in the soil, but these also were comparatively rare, and only one wasp per egg was bred out. One of these Scelionids was *Prosapegus strellus,* also recorded from Dutch New Guinea. The smaller species measured about 3.8 mm. long and *P. atrellis* about 7.4 mm.

New Hanover.

Six local parasites have been bred from material collected in the field in this area, of which three are sufficiently prevalent as to offer economic possibilities worthy of testing out in areas in which they are not already present—

(1) Two species of minute *Trichogrammatidae,* one of which, *Doirania leefmansi* (about .65 mm. long) is very general and regular in occurrence. This species was first collected in this locality in 1930 by the Entomologist. It is also recorded from Amboina and the Bangaai Islands (east of Celebès), N.F.I. The other species has only been bred on one occasion, and is evidently rare. It is not yet known whether this is a primary or only a secondary parasite of Sexava eggs.

(2) A species of *Encyrtidae* (female about 1.3 mm. long) very closely resembling *L. bicolor,* but differentiated by the apical club and four joints of the antennae of the females being white. This wasp is also general and regular in occurrence.

(3) A species of *Mymaridae* (female about 7 mm. long) is also common; males of this species are apterous (wingless) and do not leave the outer surface of the Sexava eggs; they die within half an hour after emergence.

(4) *Prosapegus atrellus* (*Scellionidae*) has been bred in this locality also, but, as in Manus, is not prevalent.

(5) A species of *Eulophidae* (female about 1.8 mm. long), very similar to that bred in Manus, has also been found in New Hanover, but is comparatively scarce.

The following summary shows the relative prevalence of the three principal species of the above, the figures being given in percentage of the eggs examined :—

Species.	Eggs collected.			
	In soil.	In epiphytes.	In palm crown.	Total.
D. leefmansi	10.7	16.3	12.9	39.9
Encyrtid sp.	5.5	5.9	4.0	15.4
Mymaris sp.	7.7	5.2	6.9	19.8
Total for *spp.* ..	23.9	27.4	23.8	75.1

These figures have been arrived at by the dissection of a very large number of Sexava eggs collected from areas where they occur freely together in the field from the three situations as above, and kept in separate containers until dissected.

Of the above parasites from New Hanover, *D. leefmansi* and the species of *Encyrtid* have both been bred through their life cycles, that of the former being 38-41 days (average 39.5), and of the latter 30-38 days (average 32.5). Colonies of both these species are being maintained for transference to our next site of operations.

So far, although the *Mymaris sp.* parasitizes the Sexava eggs freely in the laboratory, we have not been successful in breeding it through the life cycle, apparently due to desiccation. Experiments are in hand to endeavour to overcome this difficulty, and if colonies can be maintained this species also will be included amongst those transferred to the new site of operations.

New Britain.

A species of *Eulophidae* (female about 1.6 mm. long) was bred on two occasions from Sexava eggs collected from the same locality in the vicinity of Rabaul, but was not plentiful. An unsuccessful attempt was made to breed this wasp in the laboratory.

New Ireland.

A species of *Mymaridae* (less than .5 mm. long) was bred from Sexava eggs collected in one locality on the Namatanai coast, but was scarce.

Prosapegus atrellus also bred out from the Sexava eggs referred to above.

Specimens of all the unidentified species have been forwarded to the Imperial Institute of Entomology, London, for determination.

Biological Races.

It is generally recognized that various species of insects may show different habits, although morphologically the same; some of these "races" may occur in pest form while others never develop such habits.

With Sexava, it is well known that in some localities it has been present for years and never developed in "plague" form, and it is quite possible that in this pest also we must recognize the presence of such biological races.

Predators.

No insect predators of Sexava have been found to date.

There are several species of birds that prey on these pests, the most prevalent of which is probably the crow (*Corvus orru*), although the white-headed fish hawk (*Accitiper sp.*) is another that feeds freely on Sexava. Unfortunately neither are sufficiently common to be able to make an appreciable difference in the pest population in any area, although they are not to be despised as a help; other birds have also been reported to feed on Sexava.

Several species of small lizards have been observed to devour the nymphs and adults; but these, also, are not numerous.

Mechanical Measures.

The use of fires along the rows of palms (when they are not too high) on still days will bring considerable numbers of both adults and nymphs down from the crowns of the palms, when they can be captured and destroyed.

In localities where the "hoppers" come down from the palms at night large numbers can be collected very readily; the proportion of females so destroyed at these times is much greater than in collections made during the day.

Thoroughly turning over the soil will lead to the exposure of eggs to ants, &c., and will also lead to the desiccation of still more, and may bury others at depths greater than that through which the vermiform larva can penetrate.

Climatological.

The advent of a dry spell during the occurrence of a "plague" will cause a material decrease in the infestation, if it does not effectually check it. This is probably brought about partly through desiccation of the eggs due to the drying up of the surface soil and of the epiphytes, and also the decrease of water

available for the necessary requirements of the adults and nymphs. In addition to this, it has been proved that dry climatological conditions have a decided deleterious effect on the nymphs, quite apart from the decrease of water requirements.

Areas in which a definite dry season occurs every year are not as subject to severe infestation as areas in which such does not occur.

Poison Baits.

Paris green and bran baits have been set out at the base of the palms, but gave entirely negative results. This was not altogether surprising, as these insects are not ground feeders, and only come down from the palms for oviposition.

"Tanglefoot" Bands.

Experiments have been carried out with a proprietary preparation of tree "tanglefoot" to test the possibilities of "trapping" the hoppers when ascending the palms. The material was applied to the palms in bands 4 inches wide about 5 feet from the ground; in some cases two bands were applied, one a few inches above the other.

The bands remained sticky for over four months, and on nineteen palms 2,706 nymphs, mostly in the first and second stages, were caught in that period. During the course of observations on this work, nymphs were seen to cross the bands, but obviously carried a certain amount of the material away on the feet, and fell an easy prey to ants.

In following up this line of work in the laboratory it was found that, by the addition of poison to the "tanglefoot" certain destruction of the nymphs was brought about. The results may be summarized as follows:—

Sodium arsenite gave 100 per cent. mortality in 39 hours.

Mercurie chloride apparently caused a rapid paralyzing effect on the nymphs, although death did not supervene for as long as 168 hours afterwards.

Sodium fluoride gave 100 per cent. mortality within 78 hours.

Paris green gave 100 per cent. mortality in only 120 hours.

The poisons were added to the tanglefoot, which was then spread in a band on boards in the laboratory and the nymphs allowed to walk over it; in other cases the nymphs were held by the antennae and a smear of the mixture applied to the tarsi (feet) with a glass rod; the results were materially the same in the two series of experiments.

This line of research is to receive further attention.

Although the cost of treatment by such means would be relatively high, and therefore impracticable on a large scale, yet where the infestation was in a small localized area, it might be employed with considerable benefit.

Tree Guards.

At the Research Station on Mokareng Plantation tin tree guards were used on the palm trunks, but proved quite ineffective.

Ostico bands placed above the trap and also on palms without the trap, yielded approximately equal numbers of nymphs.

SUMMARY.

1. Two species of Sexava have been recorded from the Mandated Territory of New Guinea.

2. The life cycle of Sexava occupies five months or even more; the egg stage varies from 42 to more than 100 days, but is mostly under 60 days, while the nymphal stages take from 70 to more than 90 days to reach the adult stage.

3. The adults live for from four to eight weeks when fed continuously.

4. Several indigenous parasites of the egg of Sexava have been bred out, two of which present decided economic possibilities.

5. The Sexava egg parasite, *Leefmansia bicolor,* introduced from Amboina, has been established in the field both in the Manus and New Hanover areas.

DERRIS.

Its Cultural and Economic Possibilities for the Territory of New Guinea.

** By R. E. P. Dwyer, B.Sc., Agr.*

The plantation agriculture in the Mandated Territory of New Guinea is devoted mainly to coco-nuts and to a far lesser extent cocoa and coffee. Interest in the two latter crops is rapidly extending, and cultures such as kapok, castor oil, pepper, &c., are now claiming some attention.

The prevailing low price of copra has greatly reflected on the financial position of the plantations devoted to this crop. Local planters naturally believe that the immediate development of suitable auxiliary crops with a short growing period will augment their incomes and alleviate the position to some extent.

A survey of the progress made with the development of new crops was conducted by the author during a recent investigational visit to Java, Malaya and Sumatra. It was observed in all three countries that the choice of new and profitable cultures was decidedly limited.

This is largely due to the prevailing economic position and because prices for all tropical produce have fallen so low as to cause all countries to look for new and profitable avenues in plantation agriculture.

Derris is discussed in this article as a valuable source of insecticidal material receiving much attention throughout all tropical countries owing to its comparatively recent development as a valuable culture crop, and the supply of which does not exceed the demand. This culture has been the subject of many inquiries to this department both inside and outside the Territory. Such inquiries are largly traceable to an article published in the Bulletin of the Imperial Institute,[4] dealing with an analysis of samples of Derris root sent to England by the Director of Agriculture in 1933.

A number of aspects regarding the culture and economic possibilities of Derris, particularly in New Guinea, are presented in this article from sources not usually available to planters and others interested.

The extensive literature and wide interest in this subject is shown by a publication of the United States Department of Agriculture[18] where abstracts of 456 references are quoted, and it is known that many more publications on Derris have appeared since 1931.

Botany of Derris.

Derris elliptica, Derris malaccensis, and related species with insecticidal value, belong to a small sub-tribe—*Lonchocarpinae*—of the well known order *Leguminosae.* The genus Derris also known as *Dequelia* by American botanists, is widely spread throughout all tropical countries. This group also contains a number of species which have little or no insecticidal properties of commercial value.

Most species of Derris are climbing shrubs with short stems which send out numerous long slender branches, and these climb over trees and any surrounding tropical vegetation. In most instances they are shade-loving plants, which grow at low altitudes and require plenty of moisture.

The two species of Derris commercially known as "Tuba Root" in Malaya and surrounding countries and most commonly cultivated for toxic content, are *Derris elliptica* and *Derris malaccensis.*

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* The literature referred to by means of the number in brackets is cited at the end of the article, each reference being numbered to coincide with the numerical order of the literature cited.

Derris elliptica is described[19] as a scrambling shrub with black stems, the undersides of the leaflets and petioles are softly hairy and usually greyish in colour—the flowers are rose pink. Seed pods are rarely produced.

Derris malaccensis is a climbing shrub of erect habit, the undersides of the leaves and petioles are smooth and light green in colour and the young foliage is bright red brown. Varieties of each species have been isolated.

A scheme for the differentiation of the several commercial varieties of *Derris elliptica* grown in Malaya (based on leaf characters only) has been perfected,[13] which proved necessary because of the usual shy flowering and seeding habits of this plant.

There are other groups of plants fairly closely related to Derris which yield rotenone (the main toxic principle in this root) in commercial quantities, thus being a source of competition on the open market.

Two species of cubé root (pronounced coo-bay) *Lonchocarpus* species, are indigenous to British Guiana where they are known to natives as white and black hiari, and are used for catching fish in the same way as Derris is employed by natives in various countries. *Lonchocarpus nicou,* also locally termed cubé root, native to Peru, is of even greater importance.

Cubé root is collected by natives and is being sold in the United States of America in rather large quantities for commercial preparation as insecticides. Manufacturers in New York report that this product analyses 4–7 per cent. rotenone, which compares very favorably with good samples of tuba root.

Commercial sources of Derris are at present in Malaya, Sarawak, British North Borneo and the Dutch East Indies (*see* table II.).

Derris Philippensis and several other species have been collected and analysed from different parts of the Philippine Islands[2], and only a few, including the first named, contain relatively high quantities of rotenone.

Incidence of Derris in New Guinea.

There is one planter in the Bainings district of New Britain, attempting to grow Derris on a fairly large scale. In New Guinea, Derris is much prized by natives and is known as "New Guinea Dynamite". The name has reference to its use in fishing and is derived from an allied practice of dynamiting fish for food supplies, which has wide application on these coasts.

There are probably several species of Derris in New Britain, and the most prized is referred to as "Avun" by natives in Kokopo, and as "Burei" near Rabaul.

The writer has noticed that almost every native village visited in the Talasea and Rabaul districts has a few plants of true *Derris elliptica* receiving care and attention. According to the native villagers the root is placed in tins and bruised until the water is milky white, and then thrown into the sea or pool as the case may be, in order to paralyse any fish present.

There are comparatively few dense stands of Derris in New Guinea because the natives have cut out large quantities of this root in the past for use as fish poison, with little attempt at cultivation or replacement. It has been stated that there are apparently rather extensive areas of Derris south of Madang on the New Guinea mainland behind Melanu and Bogadjin plantations.

Derris Compounds and Their Uses.

Derris products have come into prominence in the group of so-called non-poisonous insecticidal preparations.

Chinese market gardeners in Malaya realized the insecticidal properties of Derris and even cultivated it for local use long before it was exported to other countries.

To control insects it was their usual practice to water their vegetables with an aqueous extract derived from the pounded roots. This is still regarded as their cheapest and most effective insecticide for this purpose.

Tests have proved it to have little toxicity to man, especially in doses applied to plants, and this applies to most higher animals, though some cases of suspected poisoning are recorded. Haag[11] quoted by Adriano[1] swallowed 150 millegrams, equivalent to 23 grains, without ill effect.

In New Guinea the plant is used by natives ostensibly as a poison, but this is believed to be more for moral effect in family questions, &c., as it does not act as a deadly poison. It does occasion severe spasms and paralysis, necessitating the use of the stomach pump by medical officers. One District Officer in the Kavieng district, some years ago issued instructions for all Derris roots to be cut out, believing that it was used as a native poison.

The secret of its use is probably that when eaten the delinquent native becomes very sick for a couple of weeks, usually without fatal effects, so that the relatives and native villagers become sympathetic and forgive them for any rash acts.

Derris has a very wide commercial application as an insecticide for controlling plant pests and insect skin ectoparasites of animals. It behaves both as a contact and stomach poison. In the first case as a contact poison insects crawling on leaves sprayed with Derris, die without eating the dust or spray because of a vaporizing compound present causing respiratory or tracheal paralysis and resulting in suffocation. It has to be ingested through the mouth parts and then absorbed to act as a stomach poison.

The ill effects of arsenical spray residue on the leaves of fruit trees and its effect on human health, where present to excess on the fruits, has recently received much attention. The conclusions resulted in some countries bringing in legislation to control the amount of arsenical spraying allowable on edible food stuffs, which greatly increased the uses of Derris and Pyrethrum.

Derris is particularly useful in the control of insects and aphids on vegetable plant food products at stages of maturity where the application of arsenical compounds may be dangerous to human health and it does not affect the leaves to the same degree as arsenical sprays. The ground up roots when ingested dry by some insects are not toxic, but may become immediately toxic on mixing with water or when sprayed on wet plants. The juice or sap when expressed from the roots is only slightly toxic to insects, as little of the toxic principle comes away with it.

The conclusions reached from actual spraying and dusting experiments with Derris and its compounds have often proved most inconclusive probably due to wide variations in toxic content of the original material and the numerous and varying methods of preparations used.

Derris compounds have been tried on a very wide range of insect and animal pests under the most varying conditions. It appears very useful as an aphicide for controlling plant aphis and is effective against thrips, biting caterpillars and spiders, &c., and is being tried in the control of insects on coco-nuts and other palms.

It is used with great advantage against animal lice, house flies, and as a larvicide in mosquito control. In animal husbandry it has proved effective against "Ox Warble Fly", poultry pests such as "Red Poultry Mite", and more recently against the "Bush Tick" which is the carrier of paralysis of dogs in Australia. An important use is as the basis of some proprietary sheep dips.

Its compounds may be applied as sprays, dusts, or dressings, and have proved particularly valuable in combination with other insecticides and fungicides. Talc, gypsum, inert clay, and finely ground tobacco dust have been used as fillers for Derris dusts, and several firms are selling mixtures of Pyrethrum and Derris. The Pyrethrum acts more quickly but loses its toxicity sooner than Derris, hence their combined value in a mixture. Mixtures of Derris with acetone, bordeaux mixture, lime sulphur, lead arsenate, soap (very wide application), castor oil, white oil, fish oil, sulphur paraffin, pyridine kaolin and kerosene have been tested in various combinations for insect control. Acetone has wide use for extracting rotenone but keeps it in fine suspension, hence resin soap, also acting as an insecticide—is used with a little gum or starch added to compound a proper spray mixture.

Chemistry of Derris.

The main toxic principle present in Derris root is rotenone ($C_{23}H_{22}O_6$) with a most complex chemical formula and which has been found very effective as an insecticide. Derris also contains varying amounts of other toxic compounds such as dequelin tephrosin and toxicarol, which are chemically closely related to rotenone. These compounds are not so highly toxic to insects as rotenone and constitute smaller percentages of the natural root, though the proportion present varies with the species and variety. *Derris malaccensis* for instance is shown by analysis to contain relatively high percentages of toxicarol, which is only one-third as toxic as rotenone against fish. Tests are being conducted in Malaya and elsewhere to determine whether rotenone alone is as toxic as where the other toxic compounds are present in greater or lesser proportions.

There has been a stupendous amount of research conducted on the chemical composition and insecticidal properties of Derris root and its components by phyto chemists, entomologists, and others, the scope of which can only be indicated in this article.

Georgi & Lay, Teik[9] in discussing the valuation of "Tuba Root", state "that there are two methods by which the roots are valued by buyers (*a*) those who buy on 'an ether extract basis', which includes the total amount of material extracted by the solvent, (*b*) buyers on the 'rotenone content basis', which method of valuation is based on the results of an investigation carried out by the United States Department of Agriculture." The first method of evaluating Derris is used mainly in respect of roots offered for sale in the United Kingdom, whilst the rotenone basis is for most part restricted to material exported to the United States of America.

It was believed formerly that *Derris malaccensis* and *Derris elliptica* had much the same toxic properties because the percentages of ether extract obtained proved very similar in both cases. The American investigators were first to point out that the ether extract of the former contained so much less rotenone than that from the latter species owing to varying percentages of other compounds present.

There is still much controversy as to whether the rotenone basis or the ether extract basis is best for commercial purposes. The prices of Derris or Tuba at Singapore are compared on an ether extract basis as against a rotenone content basis (*see* table V.), and it is seen that the sales on a rotenone basis consistently yielded highest prices.

This does not necessarily present a true picture of the position, however. The two largest British firms operating in Malaya are mainly interested in ether extract Derris, most of which is not sold on the open market hence the difference in prices noted might not be a true reflex of the valuation methods used. It is emphasized that neither the methods of analysis, commercial sampling, or the methods of selling have been accurately standardized, though research workers and buying organizations are rapidly attaining that end.

Strictly speaking, the relative toxicities of the different species and varieties of Derris can only be determined by controlled insecticidal tests combined with chemical analysis. The results of the relatively few tests of this nature already available display very conflicting results. Some species of insects, for example, are much more resistant to the action of Derris than others. Miller[16], entomologist in Malaya, has described several insects capable of attacking Derris roots in the dry state. Froggatt[7] has recorded a borer belonging to the Bostrychid species, *Xylotrips religiosus* (Boisd), as causing severe damage to dried root in New Guinea. The author has noticed an ascomycetous fungus, not yet identified, causing severe leaf spotting on New Guinea Derris.

Cockroaches have been fed on pure dry rotenone apparently without effect, rats also can eat it with impunity, but are poisoned when it is injected into the blood. It has been found that insect pests usually live on the larger tubers only, and these have been proved by numerous chemical analyses to contain much less rotenone than small sized pencil roots. This explains why buyers express definite preference and usually require fine roots of definite size. Analyses have shown that the centre part of the root contains more rotenone than the outside portions of the same root.

McCormack & Co., United States of America, in correspondence state "that they can obtain rough standardization by a system of blending". The root is milled and after every 1,000 lb. milled analyses are made, after which various lots are mixed in proper proportion. Other firms have mentioned blending with high quality root as a method of using lower quality root.

One of the great defects of Derris products containing rotenone is the loss of toxicity in storage, largely due to the decomposition of the toxic products on exposure to light.

Recent research carried out by the Council for Scientific and Industrial Research, Australia[20] indicates this loss of toxicity on exposure to light is one of photo chemical oxidation, i.e., due to the action of light and air, which occurs at a much slower rate with pyrethrums derived from *Chrysanthemum cinerariaefolium*, &c.

Recent chemical research has given very great promise of obviating this loss of toxicity on storage and certain chemical derivations of rotenone are now known which are even more toxic and decidedly more stable than the original compound. The commercial and economical application of this research is still in the experimental stages.

Analysis of New Guinea Derris.

Lenz, in 1911[15] recorded the results of successive extractions of *Derris elliptica* root from New Guinea with various solvents, and obtained an ether extract of 8.9 per cent. at room temperature.

TABLE I.—DERRIS ROOTS FROM NEW GUINEA—ANALYSIS BY THE IMPERIAL INSTITUTE, LONDON (4).

	Present samples from New Guinea.		ommercial samples of Malayan roots.
	Fine roots.	Coarse roots.	
	Per cent.	Per cent.	Per cent.
Moisture	7.8	7.4	10.2
Total Carbon Tetrachloride Extract* ..	7.8	4.8	10.4
Rotenone*	3.2	2.1	2.2

* Expressed on the moisture free material.

The results show that the rotenone content of each of the present samples from New Guinea compared satisfactorily with that of the commercial sample of Malayan *Derris elliptica* roots used for comparison. It is commented by the present author that bulk samples and the rotenone content in both cases is lower than the standard required by most buyers.

Derris Uses as a Mixed Culture.

Derris belongs to the family of leguminous plants which has nitrogen fixing bacteria present in root nodules, capable of fixing nitrogen from the air, and thus acting as a definite soil improver. It has been used in mixed cultivation with coco-nuts, kapok, cocoa, rubber, &c., in countries such as Malaya and Java, although this aspect of Derris cultivation is still in the experimental stage.

Of special interest to local planters is that Derris grows well under coco-nuts, although there are some disadvantages which accrue from their mixed cultivation. Derris roots become large and tuberous and grow down 3 feet or more after two years growth, besides growing 6 or 7 feet away from the base, i.e., where no other crops are competing. Harvesting Derris roots of correct size for marketing means digging deeply into the soil which may injure roots of other trees or crops present.

The surface roots of coco-nuts at 5 yards distant from the base may be only 1 foot below the surface, and the roots of two coco-nut palms in adjoining rows may overlap 6 feet or more. This leads to the possibility of root competition with the Derris and root injury to the palms where the two crops are grown together in mixed culture.

The mixed cultivation of Derris and young coco-nuts could be advocated for several years after planting the latter, as there is much less chance of root competition in early growth. There is a decided risk of root injury and root interference where Derris is interplanted with old coco-nuts, but the practical effect of such competition on the two crops remains to be tested on an experimental basis in this country.

Interplanting with kapok in Malaya was described by Georgi and Curtler[8] where the kapok trees were spaced 20 feet by 20 feet square. Tuba cuttings were planted in rows 3 feet apart and spaced 3 feet apart in the rows, which was equivalent to 3,555 plants per acre.

Cultivation of Derris.

Derris grows in most kinds of soils and is said to prefer a clayey loam containing a fair quantity of sand, but may even grow profitably on worn-out lands where other crops do not thrive.

The species of Derris are readily propagated from stem cuttings 18 inches long, which are usually struck in nursery beds, preferably of light or sandy soil.

Collapsible bamboo baskets, or baskets made from strips of palm fronds, have been employed in some instances for rooting the cuttings. This also allows the plants to be set out in properly made holes without disturbing their growth or giving them a setback on transplanting.

Experiments are being conducted with different kinds of composts, leaf moulds, soil, &c., both in seed beds and in the field, to increase the yield where possible.

In growing plants to develop cuttings it is preferable to train them over light poles or bamboo trelisses with *Crotalaria* or *Tephrosia* as a leguminous shade, grown in rows on either side of the trellis rows. The plants must be grown for nearly two years before the stems are ready to provide cuttings for increasing selections on a field scale. The stems must develop good firm mature bark, as immature shoots with soft bark will strike badly. Cuttings root earliest and do better in a moist lightly shaded nursery bed, and are often ready six weeks from the date of planting. If they are exposed to full sun it is advisable to remove the leaves to prevent drying from excessive transpiration.

A recent publication[5] describes the methods of cultivation adopted by Chinese market gardeners in Malaya. They plant long cuttings which have been twisted into a circle at distances of about 6 feet apart and then allow the plants to run over the land. During growth pig manure is applied to the soil and the crop is not harvested at one time, but lifted as required.

In ordinary sole cultivation[19] the rooted cuttings are transferred to the field at a planting distance of 3 feet apart each way, giving 4,840 plants to the acre. Good results have been obtained by ridging the land in rows at 3 feet apart, the soil being worked into a fine tilth during the operation.

Methods of growing and shading Derris still requires much experimental testing and experiments in this direction have been commenced at Keravat Experiment Station, Territory of New Guinea.

A promising new method of cultivation is under test at the Government Plantation at Tjipitir, West Java, where attempts are being made to develop Derris as a permanent crop. There the Derris is planted under permanent shade, spaced at correct distances for protection. Bamboo poles for support are fastened between each contiguous pair of shade trees in the same row. The Derris plants are planted in holes in the centre of the space between the trees and allowed to climb on to the supports. It is intended to dig out the roots when ready to harvest from opposite sides of the supports at alternate periods. Thus the Derris, which is naturally a fairly long lived plant, will only be lifted partially, and it is

expected that the remaining roots will keep the plant going and provide a continuous harvest for some years. The effect of root injury, and effect on yields, cost of harvesting and danger of Termite or white ant injury are the serious considerations in this method.

Harvesting of Derris ordinarily means digging up the roots, and the preparation prior to marketing is discussed elsewhere. The optimum age for harvesting Derris roots has been the subject of experimentation, and one investigation shows 23-24 months as the best age to harvest the roots, but this is subject to soil and hereditary variation. A time of harvesting experiment, where Derris was interplanted with kapok, was indicated previously under mixed cultures. Here the root was harvested at the end of 21, 23, 25 and 27 months, respectively, and yields of 1,277, 2,190, 2,697 and 3,445 lb. of root per acre were recorded at the end of each period. It was found, however, that the ether extract noticeably reduced after the 25 months period.[3] The roots may severely reduce in rotenone content after an optimum period, although the yield of root usually increases.

Manufacture of Derris.

This is mostly in the hands of proprietary firms as there are few simple methods of preparing the product for commercial use, and usually efficient grinding machinery is necessary. Where costly solvents such as ether, acetone, or carbon tetrachloride are used, there must be provision for recovery and repeatedly using the same solvent.

It is prepared as dusts, sprays, Derris extracts, mixtures with other compounds, &c., but most of the processes are covered by wide patents. Local manufacture should not interest New Guinea planters for some time to come, and hence is not discussed in this article. It will be of interest, should both tobacco culture and Derris culture expand, and essential particulars are available.

Preparation of the Roots for Market.

It is the buyers' requirements which need consideration at this juncture, and, firstly, they demand a dependable supply, and, secondly, satisfactory toxic content. Continuity of supply and regular delivery of quality root is very important, but somewhat difficult to fulfill with a culture such as Derris.

Derris is not usually subjected to any preparation after harvesting, other than drying and removal of the dirt. The usual practice after harvesting the roots is to wash away the dirt, place them in open sheds and allow to dry for about ten days. They must be thoroughly dried and stored in a cool place to prevent deterioration and entree of insect pests. The smaller roots of pencil thickness have the greatest toxic value, hence it is the recognized practice to sort the smaller from the larger roots. The preparation for shipment necessarily must be thorough and demands cheap labour.

Shipments from Malaya are usually cut into suitable lengths of about 3 feet and the Derris roots are then dried, bundled into bales measuring approximately 42 inches by 30 inches by 28 inches and weighing from 220 lb. to 250 lb. net, which are wrapped in jute bags.

Another method now used is where the roots are ground up in a suitable disintegrator and put into rubber and tea cases weighing about 100 lb. net.

In Malaya chips were made from the roots and then bagged, this proved unsatisfactory as a preparation for shipment.

Koolhaas[14] invented a method in Java where the roots are ground and pressed into cakes of very hard consistency to save space and prevent loss of toxic content.

Control of insect bores in the dried Derris is practicable by fumigation prior to shipment.

Selection and Plant Improvement of Derris.

In Malaya and Java many named varieties of *Derris elliptica* have been originated and increased from single plant selections of proved high toxic content.

In the same manner much selection remains to be done in original unselected material present in all tropical countries such as New Guinea, where this species grows naturally.

According to Roark,[17] single plant selections of *Derris elliptica* have been isolated and analysed and found to be totally free of rotenone. Some selections and samples yield 2 per cent. and others as high as 7–8 per cent. rotenone, with a total ether extract varying up to 13–18 per cent., and even 22 per cent. has been recorded.

Species or varieties of Derris may have a high ether extract and a low rotenone content and to a lesser extent vice versa, whilst selections with both high ether extract and high rotenone content are more desirable, and this constitutes an important aim in selection.

Selections of Derris of known high toxic content have been introduced from Malaya by this department and are now undergoing tests.

Work has been commenced in collecting selections of Derris from all parts of New Guinea, to determine by plant breeding and chemical analysis whether high toxic content selections can be isolated from the indigenous material.

Variation in toxic content has been attributed to soil and climate as well as hereditary differences.

Insufficient work has been done to indicate to what degree soil and climate affect the hereditary characters tending to high rotenone content which is present in some selections. A high rotenone content selection grown in one place and transferred to another place in Malaya was found by their chemist to vary considerably in percentage of rotenone present.

Yields Recorded in Other Countries.

The Malayan Department of Agriculture has indicated that under suitable conditions the yield of fine dry roots is about 1,000 to 1,200 lb. per acre.

They have recorded 1,600 lb. per acre after using chillies as a catch crop and 2,700 lb. per acre when interplanted with kapok and harvested after 25 months.

The average weight of roots per plant at their Serdang Experimental Plantation, Kuala Lumpur, has been recorded as 1 lb., whilst a loss of weight of 40 per cent. was stated to take place during drying.

In Cebu, Philippines, according to Adriano et Al[2] production has been estimated at 2,500 to 3,500 kilos of fresh root per hectare (kilogram equals 2.25 lb., hectare equals 2.472 acres, hence equivalent to about 2,000–3,000 lb. per acre). They claim that 600 kilos of dried root per hectare (nearly 500 lb. per acre) is a low average yield.

Dividing the acreage planted in Malaya into the tonnage exported in 1933, it appears that the average yield for the whole country is about 4 cwt. per acre, i.e., if the comparatively small amount used externally is excluded and if little Netherlands Indies root for transhipment has been included.

Overseas Prices.

Fuerst Bros. & Co., London, quote the price of Derris root at 31st August, 1934, as 7¾d. per lb. less 1 per cent. c.i.f.

Brown & Dureau Ltd., Melbourne, in a letter received 7th March, 1935, state that continental firms in England quoted as follows for a parcel of Tuba Derris root with a rotenone content of about 4 per cent. (without guarantee). They suggest £15 per ton c.i.f. Rotterdam, excluding duty (equivalent to about 1s. per lb. landed).

Prices appear to have varied in the United States of America from 12–20 cents per lb. According to the Imperial Institute 1933,[3] the price of Derris has fallen considerably during recent years. The spot price of Derris root in London, according to the *Chemist and Druggist*, is 8½d. per lb. (November, 1933), compared with 10d. per lb. earlier in the year.

If a yield of 1,000 lb. per acre is assumed for purpose of calculation, and the quoted prices of 7¾d. per lb. and 8½d. per lb., the gross returns per acre would be £32 5s. and £35 8s., respectively. This would be reduced to £16 2s. and £17 14s. gross returns per acre if the stated low average yield of 500 lb. per acre was harvested.

The cultivation and harvesting expenses should not be high since the plant does not need much attention.

Little accurate costing for cost of production is available from outside countries.

Adriano et Al[2] state that 600 kilos of dried Derris root will yield about 14.52 kilos only of crude rotenone crystals, but this is assuming only 2.42 per cent. rotenone. They advocate extraction of the rotenone on spot in the Philippines to avoid cost of shipment. Bower, 1930,[6] stated that "so far no suitable means have been found for extracting the toxin before shipment."

General Discussion.

Planters in New Guinea should not regard Derris as a crop which is likely to provide quick returns, largely because its culture is only in the experimental stages. Only a few original plants are available in this country, which are known to be derived from plants of satisfactory toxic content. It will be necessary to grow these for two years before cuttings will be available for increase on a field scale.

Large scale introduction of selected plant material from outside countries (e.g., Malaya) is possible, but it may prove difficult to obtain their best selections. Then there is the risk of landing the cuttings in good condition for planting and also the effect of this climate on their rotenone content is unknown.

Indigenous New Guinea plant material is being collected from widely scattered areas. Single plant selection combined with chemical analysis will be necessary before selections are isolated, which should favorably compare with the best material available in Malaya and Java.

Chemical analysis of some New Guinea root[3] showed 7.8 per cent. tetrachloride (approximately equivalent to ether) extract and 3.2 per cent. rotenone in the fine roots, and 2.1 per cent. in the coarse, respectively. This was stated to compare favorably with 10.4 per cent. extract and 2.2 per cent. rotenone present in a commercial sample of Malayan root.

The consensus of opinion amongst Derris manufacturers in England and America is that both of these samples contain rather too little rotenone for satisfactory commercial manufacture, although they could be used by blending with higher quality root.

The shipment of fine and coarse New Guinea Derris root sent to the Imperial Institute for analysis and comparison with Malayan root, represented a bulk sample. This did not indicate the value of individual samples from selected New Guinea stock, which is known to vary considerably in vegetative characters. Chemical determination of the rotenone content combined with individual plant selection preferably should be carried out by the New Guinea Department of Agriculture, and such work is under way at Keravat Demonstration Plantation.

Economic Prospects.

There is no information available as to expected yields and monetary returns from prospective New Guinea Derris culture. Inquiries instituted elsewhere by the Department of Agriculture, such as in the United States, England, Australia and Holland, have yielded much conflicting information.

It appears questionable whether most of the Derris buying is not in the hands of relatively few buyers. It is difficult to gauge buyers' requirements and obtain information as to what quantities they would absorb, or what prices they would be prepared to offer. An important consideration is the competition with Cubé root from South America, which is becoming increasingly common in the American markets.

It must be decided whether growing for rotenone or ether extract buyers, or both, is going to prove the most profitable. The indications according to prices are that high rotenone content Derris will pay best, especially for the American market. It seems that the rapidly expanding uses to which Derris is being put should ensure a profitable market in the future. It has been stated[1] that the United States imports 10,000,000 lb. of pyrethrum flowers annually, and that rotenone promises to supplement this in part and also supplement the limited supply of nicotine which it rivals as an aphicide.

The Director of Agriculture has sent, and intends sending further shipments to London and American buyers as soon as there are sufficient stocks on hand for this purpose. It will soon be possible to make more definite recommendations to planters as to the future prospects for this crop.

Derris should have decided value for native agriculture in this Territory, and requires testing in that direction.

Planters in New Guinea should not regard Derris as a culture which is likely to provide quick returns at this stage. Its cultivation is still in the experimental stages here, and there is insufficient planting material of high toxic content available for distribution.

TABLE II.—DERRIS STATISTICS (4′ 12).

Exports of Derris Root in Tons.

—	1930.	1931.	1932.	1933.
Malaya	55½	74½	167	642
British North Borneo	34½	25	(a)	(a)
Sarawak	735	108	37½	(c)
Sumatra	3	8½	2	20
Dutch Borneo	3	4	1½	

(a) Not available.

TABLE III.—MALAYAN STATISTICS.(10)

Total Crops Specified Cultivated in Malaya, 1933.

	Acres.
Federated Mayal States, F.M.S.	1,369
Straits Settlements, S.S.	2,514
Unfederated Malay States, U.M.S.	1,566
Total Malaya	3,500

Acreages under Sole Crops, 1933.

	Acres.
Perak Derris	725
Singapore Derris	350
Total	1,075

TABLE IV.—TUBA ROOT DERRIS.

Year.	Imports.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	Straits dollars.	Tons.	Straits dollars.
1930	39	11,655	90	88,176
1933	72	18,328	642	282,795

N.B.—One Straits dollar = 2s. 4d. sterling.

TABLE V.—PRICES OF DERRIS TUBA AT SINGAPORE, 1934.

(Figures Supplied by Curator Van der Koppel, Handels (Economic) Museum, Batavia).

—	Ether Extract Basis per Pikul = 133⅓ lb.	Rotenone Basis per Pikul = 133⅓ lb.
January	24C	30½C
February	25	30½
March	25	30½
April	26	37½
May	28½	37
June	30½	40
July	34½	40

N.B.—Prices in Dutch cents, 100 = one guilder; equivalent to about 2s., now worth abou' 3s. 4d. owing to exchange.

SUMMARY.

1. Derris has been the subject of many inquiries to the Department of Agriculture, Mandated Territory of New Guinea, from planters and others interested. Its economics, culture and prospects are discussed in this article, as this is a valuable source of insecticidal material which is receiving much attention in most tropical countries.

2. Derris as a source of rotenone is discussed, including species indigenous to New Guinea as is its probable competition with Cubé root (*Lonchocarpus* species).

3. Insecticidal properties of rotenone and methods of extraction from Derris as well as its use in various insecticidal mixtures are outlined.

4. Importance of selection and propagation of suitable varieties is stressed, there being wide variation in rotenone content of different varieties.

5. Methods of cultivation, uses for interplanting, and preparation of roots for market are described.

6. Chemical analysis of bulk samples of New Guinea Derris root, conducted by the Imperial Institute,[4] showed that rotenone and toxic content to compare favorably with samples of Malayan root. (Root from both sources apparently gave a somewhat lower analysis than the accepted standard.)

7. The economics and future possibilities of Derris culture are dealt with.

While it is too early to give very definite data, it appears that the rapidly expanding uses to which Derris is being put should ensure a profitable market in the future, which would allow of its development as a culture crop in this Territory of New Guinea.

Acknowledgments are due to Mr. de Veer (Selectionist in charge of perennial crop, Buitenzorg), Dr. Koolhaas (Chief Phytochemist, Buitenzorg), Dr. Van Lennep (Chief Netherlands Government Rubber Plantation), Mr. Van der Koppel (Chief Economic Museum, Batavia), Mr. G. H. Corbett (Entomologist, Malaya), B. Bunting (Agriculturist, Malaya), A. N. Olds (Agricultural Instructor, Singapore), C. D. V. Georgi (Chief Chemist, Malayan Agricultural Department), and others, for much of the information contained in this article.

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THE PREPARATION OF NEW GUINEA CACAO FOR MARKET.

(By E. C. D. Green, H.D.A., A.I.C.T.A.)

INTRODUCTION.

The attention of planters in the Territory has, in recent years, been directed towards the cultivation of crops other than coco-nuts, in order to relieve the depression in the copra market.

Inquiries show that cacao cultivation is receiving a great deal of consideration, and this crop is within the scope of most planters.

If cacao is to become an economic cultivation, then two of the main factors must not be overlooked. First, is a ready market, and, secondly, the quality of the product must be such that when offered for sale in competition with cacao from other countries, it must compare favorably.

It is believed that the first factor is governed by the second, and that a ready market will be found in Australia and elsewhere if the product is of high quality.

Recent prices realized for New Guinea cacao have been equal only to Gold Coast values, and in some instances difficulty was experienced in selling.

New Guinea produces a "fine" cacao, which should command a far better price than that paid for Gold Coast cacao, the premium given for "fine" cacao over "ordinary" cacao being due to the better methods of preparation, and the superiority of the variety grown.

Therefore, if New Guinea is cultivating a superior variety and not receiving the price which it commands, it is safe to assume that the reduction in value is due to the methods of preparation and marketing.

It is obvious, then, that it is to the interest of the planters to improve the present product, and it is hoped that the following notes will be a guide to obtaining the standard of quality required.

The market preparation of cacao may be divided into two sections, namely (1) Fermentation and drying, (2) Grading and inspection.

FERMENTATION AND DRYING.

The Council of International Office of Manufacturers of Cacao and Chocolate define the cacao bean which is required by the trade to be plump and well filled, should crumble when pressed with the fingers, have an open texture, be quite dry, and the inside light mahogany to brown in colour.

If the beans were extracted from the pod and spread in the sun to dry, an inferior product would result. The cacao would be hard, flat, a longitudinal section through the kernel would be cheesy, purplish in colour and astringent when tasted.

To obviate these defects and render the beans suitable for manufacturers' requirements, it is necessary to subject them to a process of fermentation.

To carry out this procedure, fermenting boxes and a knowledge of the methods are essential.

Fermentation Boxes.

It is preferable that the fermenting boxes are constructed of wood. In some instances concrete receptacles have been used, but experiments have shown that concrete inhibits the growth of yeasts, bacteria, &c., essential for the process.

Size of Boxes.

The size of the boxes and the arrangement of the series will depend on the amount of crop.

A box measuring 15 feet by 4 feet by 3 feet, divided into three compartments each 5 feet by 4 feet by 3 feet, would handle 10 cwt. of wet cacao in each section. Should a smaller quantity of beans be harvested each picking, then the boxes could be made relatively smaller, remembering that 6 cubic feet of wet cacao weigh approximately 1 cwt.

It is important to know that the depth of beans in the box should not exceed 3 feet, otherwise aeration is impaired and improper fermentation occurs.

Construction of Boxes.

Only seasoned timber should be used, otherwise warping, with resultant difficulty in removing the sides, is experienced.

The dividing wall between each section should be removable to facilitate transference of the mass from box to box. The ends could also be removable to aid in filling and discharging.

When assembling the boxes care must be taken to see that no metal can come into contact with the cacao.

The floor of the box can be a series of removable boards with holes $\frac{3}{8}$ inch diameter bored 9 inches apart in the form of an equilateral triangle; or grating.

The latter is to be preferred, and consists of narrow laths $\frac{1}{3}$ inch apart. The grating is removable, and may be divided into one or more sections according to the size of the box.

The boxes should be raised 6–9 inches above a concrete floor, which is slanted towards a small drain so that the "sweatings" may get away. It is important to remember that there must be a space between the floor and the bottom of the box to allow for a free circulation of air.

Period of Fermentation.

The period required for efficient fermentation depends on many factors, such as degree of pod ripeness, type of cacao, depth of boxes, stage of crop. Beans from fully ripe pods ferment quicker than those from just matured pods. Criollo types require less fermentation than Forastero. The shallower the mass in the box the quicker the fermentation. At the commencement of the crop season fermentation is retarded on account of the physical condition of the mucilage covering the bean.

No definite time can be laid down for the duration of fermentation, and the period at which the beans are removed from the boxes will depend upon the experience of the planter. However, there are certain signs that can be followed. When the beans are first placed in the fermenting boxes they are covered with a whitish pulp. During the process, the colour changes to brown, and the liquor formed flows away from the box; also as the pulp ferments it is to a large extent destroyed. If the outer and inner colour and plumpness of the beans are observed it will be noticed that at the completion of fermentation the outer colour is reddish-brown, and the inner colour a light walnut to cinnamon.

Method of Fermentation.

Only fully ripe pods should be picked if a uniform sample is to be produced. A. W. Knapp* shows that the seeds from unripe pods produce on fermentation a gummy and mucilaginous pulp with an unpleasant odour. The beans on drying are small, flat, and shrivelled, the shell is hard, cotyledons hard, colour woody, and on roasting there is a sour odour and flavour. Over-ripe beans, on the other hand, have little pulp and the shell in many cases is frail and brittle.

There is also the possibility with over-ripe beans that germination has commenced.

After picking, the pods are broken, the seeds extracted and transported to the fermentary. Only wooden receptacles should be used for transportation, and before placing the cacao in the box it requires to be picked over and any placenta (central core), portions of shell, &c., removed.

Every endeavour should be made to fill the primary box each time. If this is not possible, then the beans in the partially-filled box are not made into a conical heap, but spread out and covered with banana leaves.

When the cacao from the following day's breaking is brought in, it should be placed in another box. This box is filled with fresh beans until there is sufficient quantity to fill one box when the beans from the previous day are placed with it. The transference of the small quantity from the first day should be made on the afternoon of the second day or morning of the third day. The box can now be covered with banana leaves and fermentation allowed to proceed in the usual manner.

As fermentation continues, transference from box to box is carried out every alternate day, until the process is completed. During the change over the beans should be mixed as thoroughly as possible with a *wooden shovel*.

The writer has observed that the common practice adopted in the Territory is to turn every day, and sometimes twice per day. This practice is quite all right providing no reduction in the temperature of the mass occurs. However, tests carried out on Kulili Plantation, Karkar Island, have shown that alternate days give better results.

It must be remembered that in the early stages of fermentation sufficient heat must be generated to prevent germination of the beans. Should germination occur, then a small hole is noticed at the germinating end of the bean when it is dry. This small aperture allows for the ingress of vermin whilst in storage.

Good fermentation of the bean is responsible for the prevention of germination, a reduction in the astringent and bitter taste, a uniform change of colour, development of aroma which is absent in fresh beans, and later, after drying, a fine "break."

Bad fermentation, on the other hand, is manifested by the lack of heat developed in the mass, no uniform change in colour of the bean, mildew of the beans in the boxes and a bad odour. On drying, the bean has an excessive adherence of mucilage, a cheesy "break", lack of aroma, is astringent, and there is the likelihood of a "germination aperture."

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* *Cacao Fermentation in West Africa*, by A. W. Knapp. Bulletin of the Imperial Institute, November, 1934.

Washing.

It is the practice in certain countries to wash the beans after fermentation and before drying. At the present time the question of washing is very controversial. It is recognized that a loss of weight occurs on drying, and the shell is rendered more brittle and cracks easily, but it is felt that the trade requirements should be tested before any definite recommendations are made either in favour or against.

Drying.

After completion of the fermentation process the beans are dried. There are two methods that can be adopted, namely, (1) sun, (2) artificial.

Sun Drying.

The type of sun drier preferred is one with a large wooden platform covered with a movable galvanized iron roof.

It is desirable that the drying floor be some height above ground as an additional aid in controlling mould during drying.

A drying platform measuring 30 feet by 20 feet should be sufficient to handle the beans fermented in a box 5 feet by 4 feet by 3 feet, approximately 54 feet of drying space being required for each hundredweight of wet cacao.

During the first half to full day after placing the beans to dry they must be spread thinly, and constantly "walked" or agitated with a wooden rake. The reason for spreading thinly is to drive off as much surplus moisture as quickly as possible.

The cacao must be constantly "walked" throughout the whole period, in order to obtain uniform drying.

"Walking" may be described as follows:—A labourer moves through the beans first in one direction and then in the opposite direction, the beans being thrown into ridges with the feet, a portion of the floor being always exposed, so that the beans are exposed on all sides to the sun, and the floor is kept dry.

The beans should be heaped for the first two nights. This aids the further slow fermentation which takes place, and assists greatly in obtaining a uniform product.

In some cacao-producing countries such as Trinidad, it is customary to "dance" the cacao, and the operation is carried out in the early morning three to five days after drying commences.

The object of "dancing" is to spread the mucilage adhering to the beans evenly over the surface, give the beans a polish, and to remove mildew.

The correct time to dance depends on the experience of the planter, and can only be ascertained by tests. Should the beans be too soft they may become unduly flattened, and if drying has proceeded too far, then breaking and cracking are liable to occur.

The method adopted is to make conical heaps each containing 4 to 5 cwt. of beans. The heaps are then sprinkled with water (about 1 gallon per cwt.) and the labourers trample the beans with a sliding motion of the feet. A conical-shaped head must be maintained all the time. "Dancing" is discontinued when a polish appears, which is usually in half to one hour.

After "dancing" the beans are re-spread and drying allowed to continue until completion. The period of drying will depend on the weather, under normal conditions five to seven days are sufficient.

Cleanliness of the drying floor is essential. Each morning it should be scraped and broomed to remove any adhering mucilage or dirt. Scraping is particularly necessary during the first few days of drying.

If mildew is very apparent, then the floor may be lightly sprinkled with water containing a weak antiseptic, and afterwards dried before spreading the cacao.

Artificial Drying.

Sun drying is to be preferred, but where conditions are unsuitable hot air can be utilized. It is generally agreed that the changes which occur during fermentation are continued during drying. However, if the temperature is too high (and it can quite easily occur during artificial heating), no continuation of fermentation takes place, and the percentage of inferior beans are increased. Should artificial drying be necessary, then an even temperature must be maintained, and the beans frequently turned as in sun drying.

The drying of cacao with copra, or in driers used for copra, is not advisable for many reasons—

(*a*) There is absorption of copra odour by the cacao.

(*b*) The period of drying for copra is, in the majority of instances, much faster than cacao.

(*c*) At no stage during drying should the beans come into contact with metal such as is used for copra trays.

(*d*) The type of copra driers used in the Territory does not permit the constant turning that cacao requires.

GRADING AND INSPECTION.

The world markets demand graded produce, and it should be realized that, if New Guinea cacao is to become favorably known and enter into competition on the open market, definite grades must be submitted.

It is to the interest of the producer that voluntary or compulsory grading be instituted.

There are various types of mechanical graders available, which could be utilized by the planter if his production warranted the expenditure. On the other hand, should production be small, then hand grading could be cheaply and efficiently carried out. From the time pods are broken in the field until the beans leave the drying platform, a certain amount of hand picking could be done. Later, prior to bagging, the parcel could be finally thoroughly and accurately graded.

EUCALYPTUS NAUDINIANA.

(By C. C. Marr, H.D.A., Inspector and Instructor, Department of Agriculture.)

Commonly known as Kamarere, this species of eucalypt comes under the category of giant gum, and it is pecular to the Territory insofar that it occurs only on the island of New Britain.

Several theories have been advanced as to its source of origin, the most likely of which being that it has been transported by some unknown means—probably by sea—south from the Philippines, as these are the only other islands in the Pacific upon which this specie are to be found, but it certainly has not come from Australia.

Kamarere is a sclerophyllous species occurring only on certain types of soil, and under certain conditions, and is not a dry country tree. It is a fine riverside type of forest, and thrives best in pure stands, on the alluvium in a valley, which is flat enough to be subject to annual flooding in the rainy season, i.e., the north-west on the north coast, and the south-east on the south coast of New Britain. The land must be sufficiently well drained to clear itself of water between floods, otherwise the tree becomes stunted, gnarled and asymmetrical in the water-logged portions.

There are three other species of eucalypt found in Papua and New Guinea, namely, *E. Papuana, E. clavegera,* and *E. alba.* These are dry country eucalypts, and have not the same commercial value as Kamarere.

On the islands of New Britain, *Eucalyptus naudiniana* is to be found growing in narrow strips along the banks of many rivers, a fringing forest, itself fringed by the rain forest proper, and it is a large patch that carries 2,000 trees. But possibly the largest stand of all was on the Torio River, Baining district, which yielded timber for nearly twenty years.

The rivers along the north coast, upon the banks of which Kamarere is to be found, are Torio, Korindindi, and Apei, in the Kokopo sub-district; Tia and Gula-gula in East Nakenai (also an area at the base of Mount Likuranga); Makavo and Sulu in Central Nakenai, and Kapiura in West Nakenai. On the south coast of New Britain, Pulia and Ilak rivers, dividing Arawe and Rauto divisions; Navaru, in Rauto; Amgen, Ania and Pavalo, in Amio; Porlo and Tortu in Lorte; Wunung and Esis, in Waterfall Bay; Berg Berg, Tigul, and Tigien, in Mengen; Matpa, Yelut, Siplong, and Ipp, in Sulka; and Henry Reid, Powell, Mavilo, and Merai Rivers, in South Bainings.

In appearance, a forest of Kamarere resembles that of a mountain ash forest of Victoria, except of course that the surrounding undergrowth is more dense. The trees shed their bark in the same way, and the colouring of the trunks is also similar. The crowns carry more spreading foliage, whilst the leaves do not droop as is the case with the more sclerophyllous of the gum species, and are not so leathery in texture.

Kamarere is a fast grower, and in seven years will attain a diameter of 6 inches, and a height ranging from 25 to 30 feet, and, once established, no tropical vegetation can compete against it. The only species superior to it in growth—and then only on water-logged soils—is Erima *(Octomeles Sumatrana)*, which casts such a dense shade that it is impossible for Kamarere to thrive under it.

Kamarere is similar in many respects to the *Octomeles* species, but is a much more valued timber. The latter, however, has a distinct advantage over Kamarere in that it is not so subject to damage by fire, and has also the additional advantage of being able to thrive equally well in less well-drained soils.

It is seldom that one is able to obtain an unrestricted view of the giant trees, as the lower story of purely rainfall species obscure the view of the gum trunks to a large extent, whilst the crowns of the Kamareres are entirely hidden from view. Often when navigating a river or stream upon the banks of which the species is growing, the giant trees are clearly seen towering over the few tall rain forest species that grow in social formation with them, and leaving the lower story quite dwarfed almost 200 feet below. When seen from a river, such a sight as this is very fine, as the delicately coloured trunks of a curious green and blue and mottled pink colour contrast vividly with the rich greens of the surrounding tropical undergrowth.

Some idea as to the size of the individual trees will be gathered from the following measurements of a felled tree, which was cross-cut into eight mill lengths, ready to remove to Korindahl mill:—

1.	Log	20	feet	in	girth,	and	8	feet in length.
2.	„	18¼	„	„	„	16	„	„
3.	„	15	„	„	„	18½	„	„
4.	„	14	„	„	„	19½	„	„
5.	„	13	„	„	„	18½	„	„
6.	„	12½	„	„	„	20½	„	„
7.	„	11½	„	„	„	18½	„	„
8.	„	11	„	„	„	17	„	„

The total length of the log was therefore 136½ feet. The total solid cubic contents worked out at 2,120 feet, or 25,440 super. feet, and the form, factor, or taper of the log is practically 0.5. This example is not an exception, for many trees have yielded a larger milling log than 140 feet.

In the above case, about the top cross-cut came 45 feet of crown log, which is usually too knotted for milling purposes, and at 181 feet sprang the main bifurcation of the crown, which spread into innumerable branches to a height of another 50 feet, making the original height of the tree 231½ feet.

The number of Kamarere trees to the acre vary from one to twelve, but the average, both on the north and south coasts of New Britain, approaches eight in first quality forest.

For the above figures, I am indebted to the Inspector-General of Forests for the Commonwealth of Australia, Mr. C. E. Lane-Poole, who, during his visit to this Territory in 1924, had occasion to visit the Open and Wide Bay districts, in which two mills were operating. Both plants have since been dismantled and re-erected elsewhere. The Vunapope Catholic Mission have transferred their operations to the slopes of Mount Likurangua (Father), in East Nakanai division of the Talasea sub-district, and have erected the old Korindahl mill, with extensive modern additions, on the beach at Ulamoa, and this factory is in constant use preparing sufficient timber to meet their own requirements throughout the Territory.

The Wide Bay mill, previously situated in Henry Reid Bay, has also been dismantled, and is now in the course of erection on the banks of the Wunung River, Jacquinot Bay, sub-district Gasmata.

In Mr. Lane Poole's Preface on the *Forest Resources of the Territories of Papua and New Guinea,* he writes:—

"The possibility of commercial forests on the smaller islands seemed less than on the main island, but on New Britain there are still small areas of profitable forests of *E. naudiniana,* the tree that for many years has yielded the best general building timber for Rabaul and outlying stations, otherwise the islands were disappointing.

"Australia's tropical dependencies, while offering no prospect of immediate gain to large saw-milling interests, possess forest potentialities of a high order. The range of forest regions extends from the mangrove swamp at sea level, through the main forests of the low lands, on to the oak of the hills and the pine forests of the mountains.

"It is nature's very abundance that has made the forests of these Territories unprofitable.

"Less species, and some pure stands, are what are wanted, and here is where the forester can assist nature. In this splendid growing climate there is no reason why Australia should not establish forests to supply a large part of her timber requirements."

[Article for publication by C. C. Marr, H.D.A., Inspector and Instructor of the Department of Agriculture, Territory of New Guinea—

EDITORIAL NOTE.—In discussing the value of this timber with Mr. E. Knox, Director of Public Works Department, he informed me that it was of comparatively little value for bridging, decking, or other places where fully exposed to the weather. It is, however, well suited for indoor work in houses, and for furniture.—G.H.M.]

METEOROLOGY.

Meteorology, the science of the atmosphere, the term usually being used with reference to the study of all influences affecting the weather conditions and climate, begins with observations, taken over a long series of years, of all kinds of natural atmospheric properties, such as temperature, pressure, wind direction and velocity, state of the sky, humidity, atmospheric electricity and ionization, and so on.

These observations are taken at as many stations as possible.

The meteorologist reduces this enormous mass of data to manageable dimensions by taking *averages* or *means*; the mean may be taken over the whole year, or over parts of it, such as halves or single months. Meteorology is largely a science of such averages.

The results derived from meteorological records are constantly being consulted for information regarding climatic conditions by persons in practically every walk of life. The enumeration of the avenues of social and industrial activity in which climatological data are of importance would consume much space, and could never be complete, as fresh ones are continually being found. Among the more important, however, are agricultural, aviation, pastoral industries, public health, and scientific research. In the case of the introduction

of the cotton industry into Australia, for instance, the first step was to discover, from their climatological characteristics, what places should be expected, in the light of experience elsewhere, to be suitable for its growth. Again, certain tropical diseases are found to be confined to places with rainfall above a certain limiting value. The medical organizations are thus forewarned as to the directions in which these diseases are likely to spread, as well as having information which may suggest models of attack on them. In the securing of reliable observations, the Meteorological Bureau is largely in the hands of observers. Poor returns mean a great deal of extra work in the office in the checking and correction or rejection of faulty observations, and in endeavours to supply missing ones. No one of the various observations listed in the routine can be considered unimportant; each may be required for some special investigation. Unreliable observations are a permanent blemish on the records of a station, and observers can be sure that their sins in this direction will ultimately find them out. Unfortunately, no opportunity of rectifying them can occur. Nothing is so depressing or so calculated to waste the time of an investigator as unreliable records. The variations to be dealt with in comparing different seasons or places, or in other researches, are often very small, and any persistent error becomes important. As an example, it may be mentioned that close relationships have been shown to exist between the deviations from normal of the monthly mean pressure at Darwin and the seasons in the Dutch East Indies and Australia, yet these deviations extremely rarely exceed 0.05 inch.

PHENOLOGICAL OBSERVATIONS.

Phenology is the study of the sequence of seasonal changes in nature. All natural phenomena, such as the first flowering of uncultivated plants, the migration and song of birds, ripening of fruit, the appearance of butterflies, caterpillars, insects, and so on, are included. Interesting results have been obtained from the study of these phenomena in England and the United States of America especially. Observers should include their observations of such happenings in the weather notes.

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